POWER

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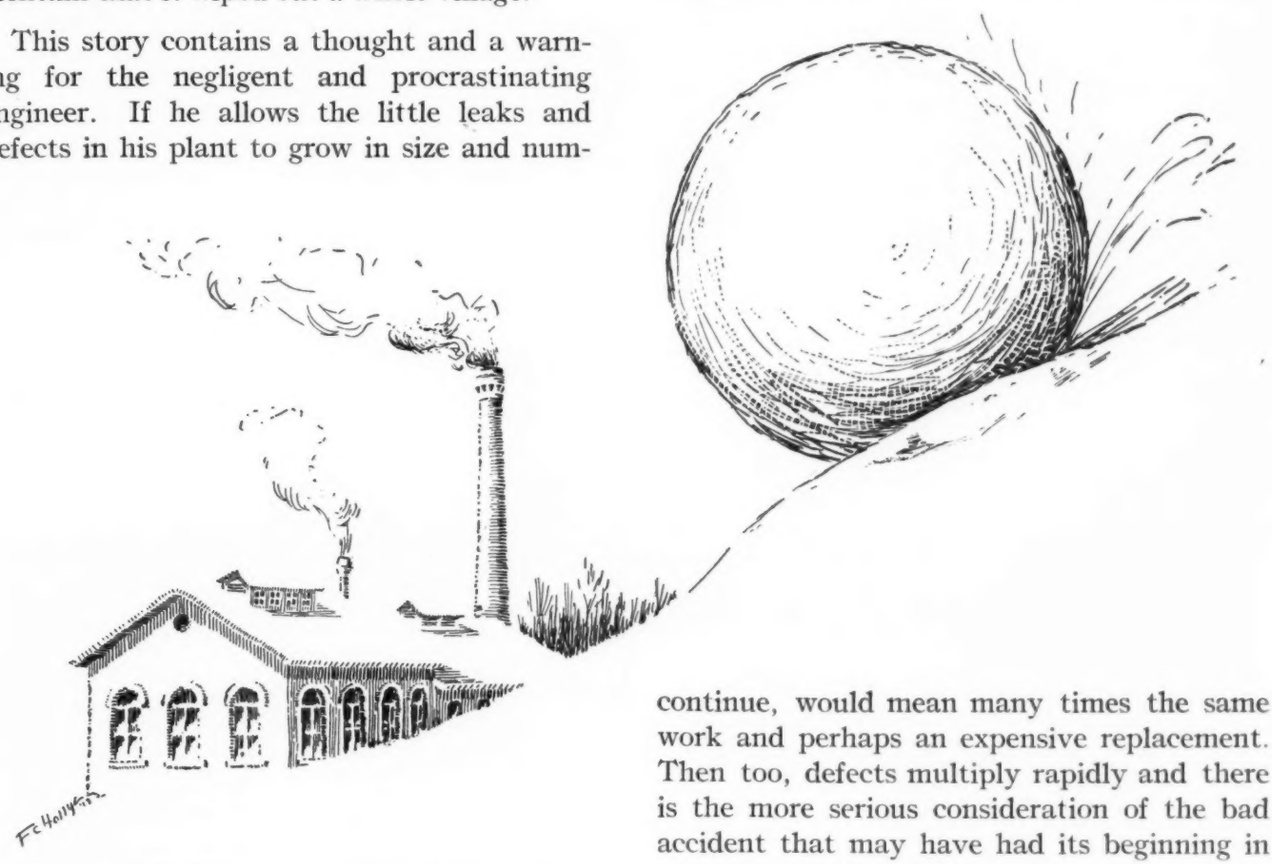
Negligence and Procrastination

THEY are few who have not heard the fable of the children innocently starting the snowball, which, rolling down the mountainside, attained such a size and momentum that it wiped out a whole village.

This story contains a thought and a warning for the negligent and procrastinating engineer. If he allows the little leaks and defects in his plant to grow in size and number, some day the accumulated mass will gain such magnitude as to engulf the plant, and the engineer will sit beneath the debris, as at the foot of the mountain, appalled, his energy and volition gone. From habitual disuse he will be unable to cope with the problems before him, and worse still, he will doubtless learn, when too late, that his influence with his employers is lost and that they would not trust him to spend the money needed to pull the plant out of the mire.



Often it takes but a few moments to permanently repair a defect which, if allowed to continue, would mean many times the same work and perhaps an expensive replacement. Then too, defects multiply rapidly and there is the more serious consideration of the bad accident that may have had its beginning in a comparatively small way.

Negligence and procrastination in small things culture the germ of indifference in larger and more important affairs, and the engineer who sits contentedly by and fails to attend to the little defects in his plant is paving the way for his own downfall and another's opportunity.

[*F. C. Holly, Memphis, Tenn.*]

Appalachian Hydro-Electric Development

By Warren O. Rogers

SYNOPSIS—This development will consist of five power-plant installations on the New River, Va. Two of these have been completed with a total electrical output of 29-000 hp. When the five plants are in operation the combined output will be 75,000 hp. Vertical water turbines, of the single-runner type, are directly connected to internal revolving-field alternating-current units, generating current at 13,200 volts.

Among the hydro-electric developments of the South, worthy of special notice, is that of the Appalachian Power Co. This company was organized in May, 1911, to develop the water power of the New River, Va., and distribute it by electric transmission through southwestern Virginia and southern West Virginia.

When completed, this development will consist of five dams and power houses to be known as Nos. 1, 2, 3, 4 and 5. They will all be built on the New River in Carroll and Pulaski Counties, Va. The aggregate water head will be 225 ft. and the total capacity of these plants will be 75,000 hp. Already developments Nos. 2 and 4, with a combined output of 29,600 hp., have been completed.

Development No. 2 consists of a dam, the main spillway of which is 504 ft. long and the low spillway 198 ft. long. The power house is built in one end of the dam, the overflow of which is approximately 50 ft. in height. The dam is built directly across the river. An auxiliary spillway above the power house has been constructed by cutting through a ridge and discharges into a natural sluiceway back of this ridge; this saved approximately 200 ft. of dam work. The dam is concrete and the power house brick and steel. There are five hand-operated and one motor-operated 6x30-ft. Tainter gates in the main spillway dam, and nine spans of flashboards. The low spillway dam has six spans of flashboards, which can be applied to a height of 8 ft. The total length of spillway is 702 ft. There is also a sluice duct for passing drift wood at the end of the power house. The tailrace is 400 ft. long, 90 ft. wide and has an average depth of 12 ft. Approximately 11,000 cu.yd. of excavation was made.

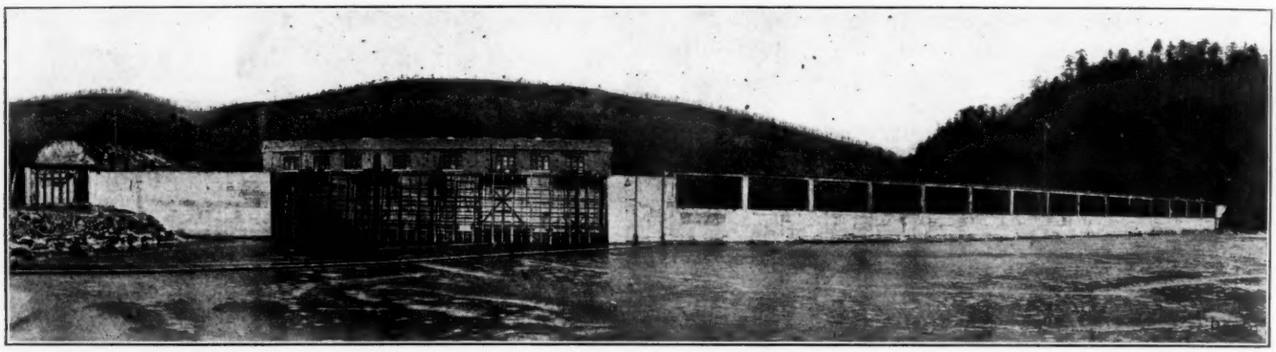


Fig. 1. View of No. 2 Plant and Spillway Dam from Above

Fig. 2. No. 2 Power Plant and Spillway from Below

Power House No. 2

There are four 5000-hp. (electrical) vertical-shaft units in this power house, a view of which from above and below the dam is given in Figs. 1 and 2. The waterwheels are of the single-runner Francis type. The wheel rests on a circular concrete foundation, and water enters the wheel casing through a spiral-shaped casing formed in the concrete of the foundation. This construction is shown in Fig. 3, which is a view in the wheel pit.

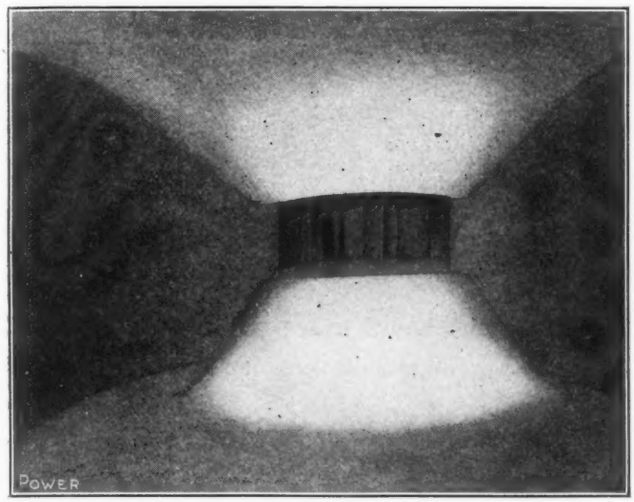


Fig. 3. Concrete Wheel Pit

These four waterwheels are coupled by vertical shafts to four 4000-kw., 13,200-volt, three-phase, 60-cycle generators of the internal revolving-field type. The speed is 116 r.p.m. The water from the wheels discharges through concrete draft tubes into the tailrace in the river bed. Water is admitted to the waterwheels through eight 14x 25-ft. motor-operated, screw-actuated sluice gates. With the flashboards in place the average head of water to the wheels is 53 ft. The Tainter gates and flashboards are for storing the water and regulating the head. By this arrangement ample water can be stored above the dam for operating the plant at any daily load factor.

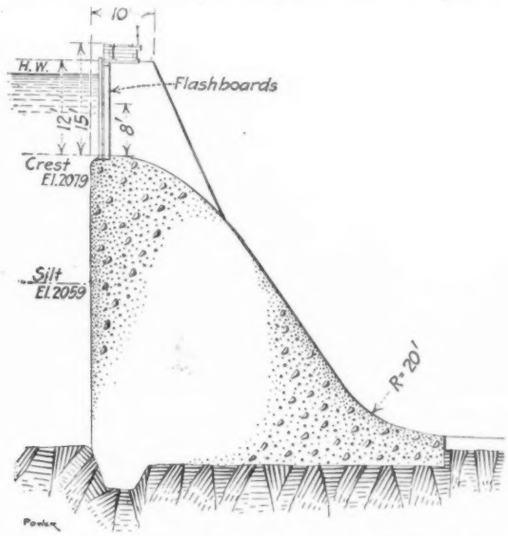


Fig. 4. Cross-section of Spillway Dam, No. 4 Development

Exciter Units

Between Nos. 2 and 3 generators are two water-turbine-driven exciter units. The wheels are of the inward discharge, single-runner type and are rated at 430 hp. each. They are set vertical and are shaft connected to two 600-amp., direct-current, 250-volt generators, running at 330 r.p.m. The speed of the units is controlled by a

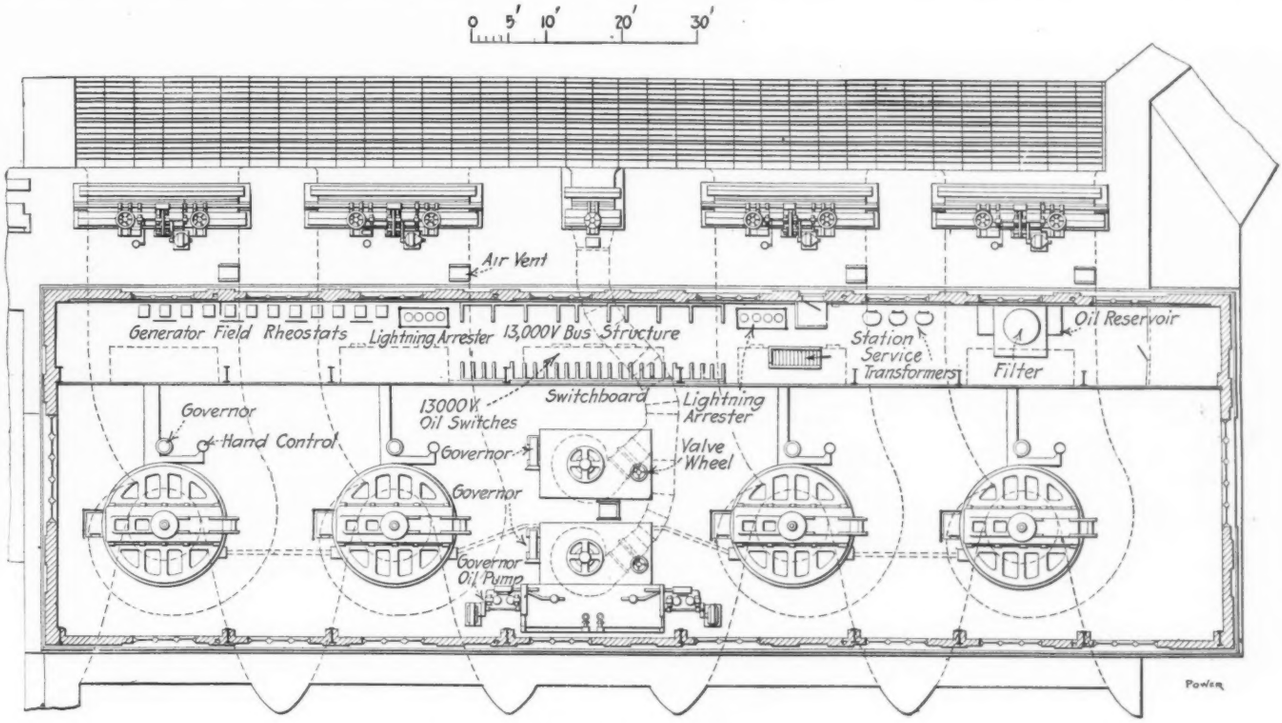


Fig. 5. Plan of No. 2 Power House

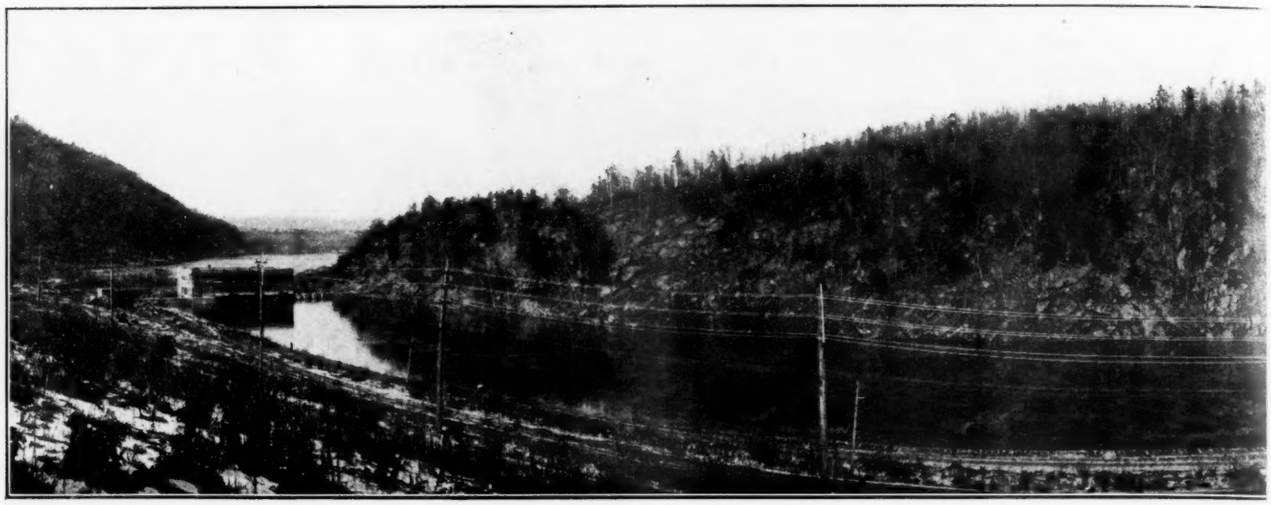


FIG. 6. PANORAMIC VIEW, SHOWING NO. 4 POWER PLANT,

special type of oil-actuated hydraulic governor. The same type of equipment is installed in No. 4 power plant, the only difference being that in the latter plant the two exciter units are located at one end of the generator room, and are of slightly smaller capacity.

OIL PUMPS

Both power houses contain two triple-plunger, motor-driven oil pumps for operating the governors. The motors are of the induction type and of 25 hp. capacity. They operate with three-phase, 60-cycle current, of 220 volts, at a speed of 845 r.p.m. The motors are gear connected to the pump crankshaft.

AIR COMPRESSORS

A 7¼x3¾x6-in. motor-driven air compressor is at one side and at one end of each plant. The 10-hp. motor is of the induction type. It operates with three-phase, 60-cycle, 220-volt current, at a speed of 1145 r.p.m., and is gear connected. The air is used to maintain a uniform pressure of 200 lb. in the tanks of the oil system supplying the turbine governors.

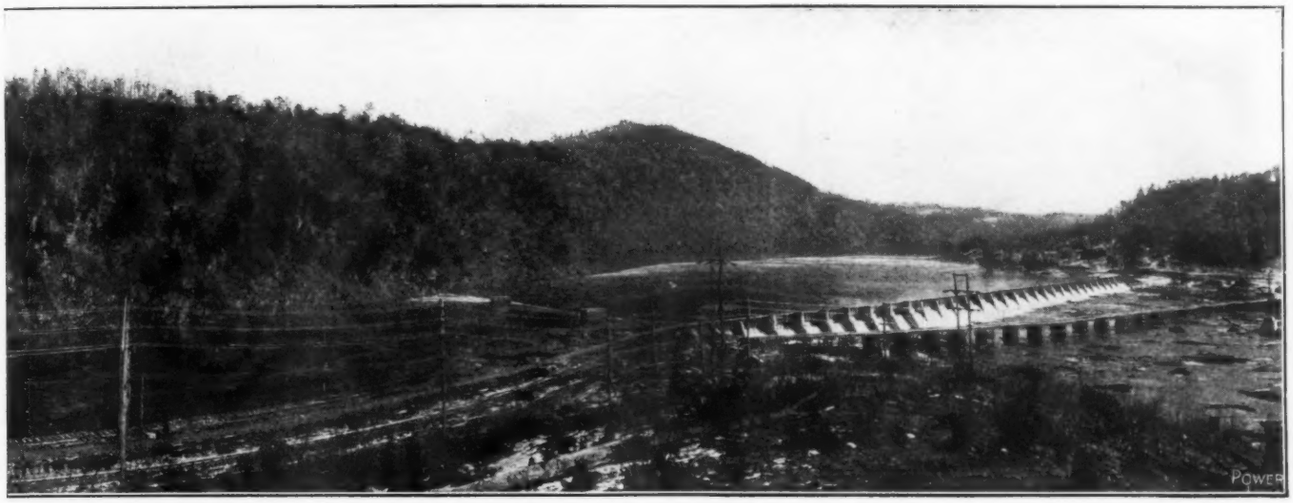
No. 2 building is brick with concrete foundations. It is 162½ ft. long and 89½ ft. wide from the rack to the end of the draft tube. As the electrical equipment is practically the same in both plants the description of No. 2 installation will apply equally well to No. 4.

A cross-section of No. 2 spillway dam is shown in Fig. 4, and a plan view of No. 2 power house in Fig. 5.

NO. 4 DEVELOPMENT

Although No. 4 development is the smaller of the two, it is of no less interest. It is between Mountain Island in the New River and the river bank. The spillway dam is at the upper end of the island, extending from the south shore of the island to the south shore of the river; the power house is at the other end of the island and it and its dam extend from the north end of the island to the north bank of the river. The island thus forms a natural headrace to the power house.

FIG. 7. NO. 4 POWER PLANT FROM ABOVE THE DAM



HEADRACE AND SPILLWAY DAM ON THE NEW RIVER, VA.

The spillway dam, which is built across the main channel of the river, is 1005 ft. long. It has six spans of Tainter gates and 24 spans of flashboards designed for 6½ ft. height. This dam diverts the water to the power house which, with the retaining dam, is at the lower end of this natural headrace.

Below the power house is a tailrace 1900 ft. long, 60 ft. wide and 12 ft. deep. This necessitated the removal of 66,000 cu.yd. of rock. This tailrace provides for an additional head of 15 ft., giving a total average head of 38 ft. Fig. 5 is a general plan of No. 4 development, Fig. 6 a panoramic view of the headrace, spillway dam and power plant, and Figs. 7 and 8 are views from above and below No. 4 power house. The building is a brick and steel superstructure, 126 ft. long and 34 ft. 4 in. wide, with a solid concrete foundation. The equipment comprises three 3000-hp. units, with vertical-shaft, single-runner waterwheels.

Mounted on the upper ends of the shafts of these wheels are three 2300-kw., 13,200-volt, three-phase, 60-cycle, internal-wound, revolving-field generators; the speed of each is 97 r.p.m. Fig. 9 is a cross-section of No. 4 power house. Figs. 10 and 11 are views of the generating units in plants Nos. 2 and 4.

The special type of double floating-lever governor used is operated from the generator shaft, by bevel gears and shafting. It is oil controlled, and operates a piston and a lever connected to a rocking ring above the outer casing of the waterwheel. The rocker ring operates the arms attached to the stems of the 20 gate vanes set in the inlets of the waterwheel casing. As the speed of the wheel increases the governor closes the gate vanes enough to shut off the flow of water to the wheel and to maintain a constant speed. If the wheel tends to slow down the vanes are opened.

The exciter waterwheels have 14 gate vanes, similarly controlled. The generating and exciter units in both plants are governed in the same way. The shaft of each unit is hung on roller bearings at the top with two steadying bearings below the generator. These bearings are lubricated by a gravity-flow oil system, oil from the bearing flowing to a well and is pumped to the bearings again by a small rotary pump, belt driven from the generator shaft.

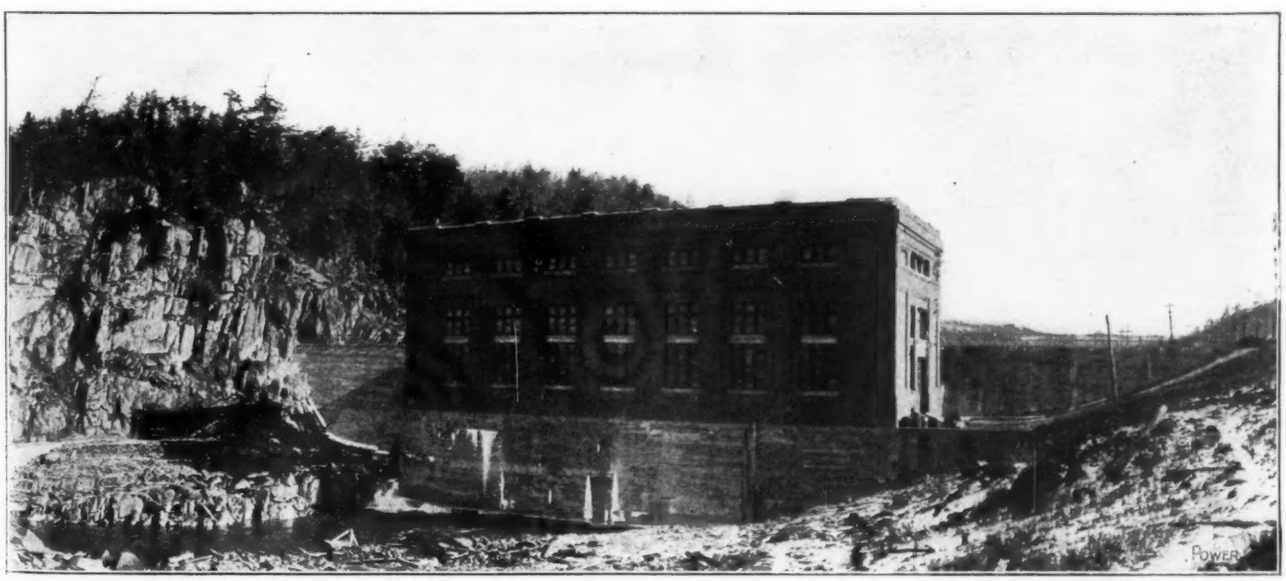


FIG. 8. NO. 4 POWER PLANT FROM BELOW THE DAM

The waterwheels operate with a head of 38 ft. Water is admitted from the headrace to each wheel pit through two 14x25-ft. motor-operated, double-screw lift gates. The

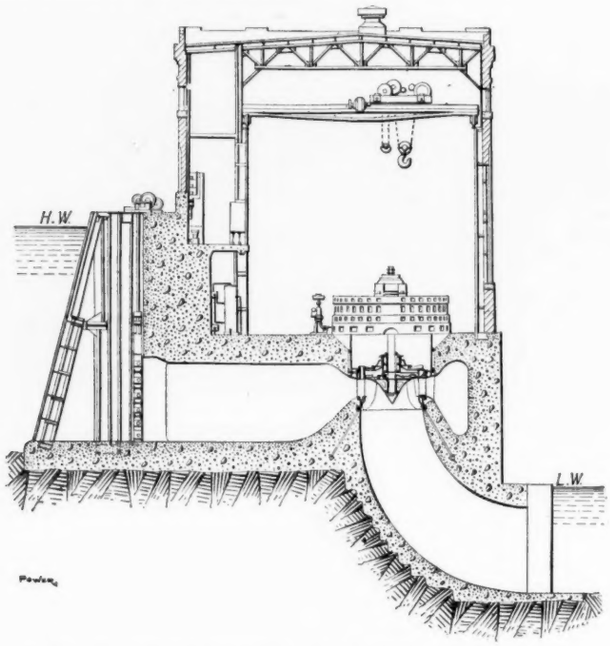


FIG. 9. CROSS-SECTION OF POWER HOUSE NO. 4

wheels set on a concrete base, the walls of which are 4 ft. thick, with a draft tube in the center.

Each generator is equipped with an indicator to show the gate opening, also a speed tachometer. In case of accident to the governor and when starting up the machines, the flow of water to the waterwheels can be controlled by hand.

ELECTRICAL CONTROL APPARATUS

In both plants the switchboard apparatus controls only the generators. The switchboards are at one side of the building. Back of them are the busbars, in concrete isolated compartments. All oil switches are remote controlled and are of 13,200 volt capacity. They are on the concrete balcony above the switchboards. The field rheostats are on the balcony, also the lightning arrester with the helical choke coils on the two No. 000, 13,200-volt

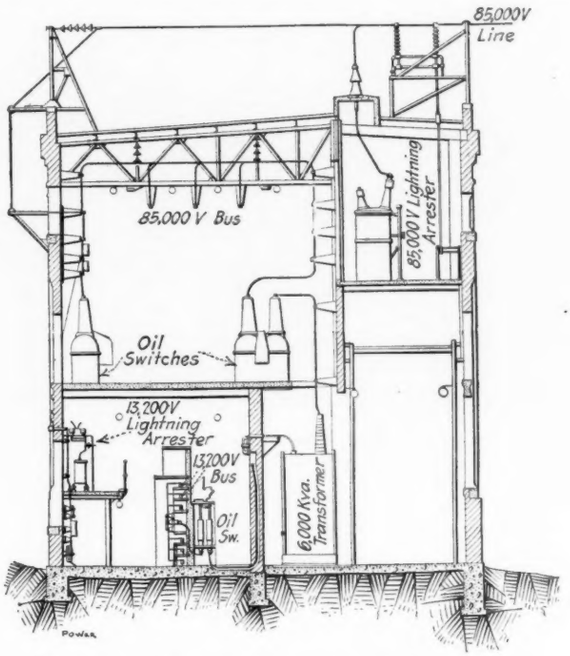


FIG. 12. SECTION THROUGH SUBSTATION

lines which extend to the transformer house near No. 2 plant.

EXCITER UNITS

Both exciter units are at the end of the generator room. Each is of 250 kw. capacity and generates 250-volt current. The waterwheels are of the inverted, single-runner Francis type, each of 250 hp. capacity. The oil pumps and air compressor are of the same design and size as those of the No. 2 development.

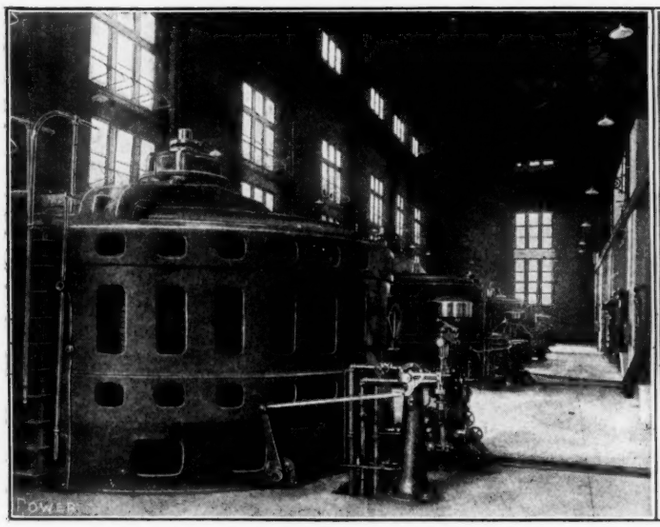


FIG. 10. NO. 2 GENERATOR UNITS

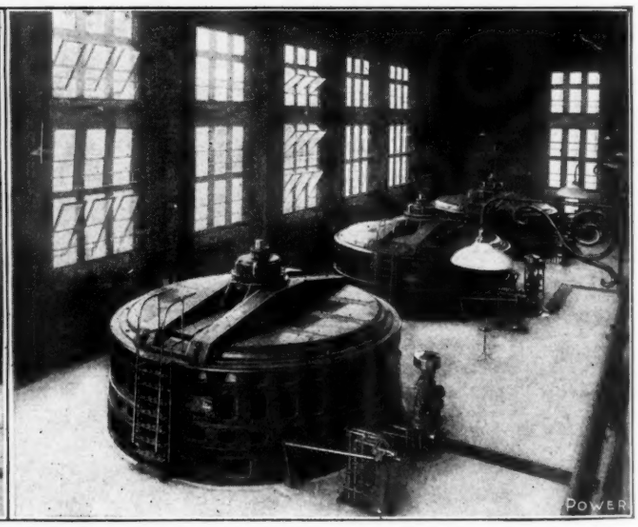


FIG. 11. NO. 4 GENERATOR UNITS

TRANSFORMER HOUSE

Electrical energy from both power plants is carried by overhead lines supported by wooden poles to the step-up transformer house adjacent to No. 2 development. A

cross-section is shown in Fig. 12. Here the electrical energy is transformed from 13,200 to 88,000 volts and distributed over the high-tension transmission system. This transformer house is designed for ultimate extension, so that all of the power from the Nos. 1, 2, 3 and 4 developments will concentrate at this house and be regulated and distributed from it. Fig. 13 illustrates the arrangement of the choke coils.

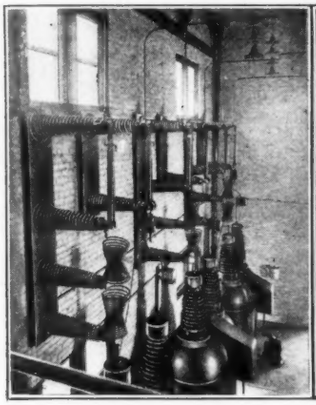


FIG. 13. CHOKE COILS

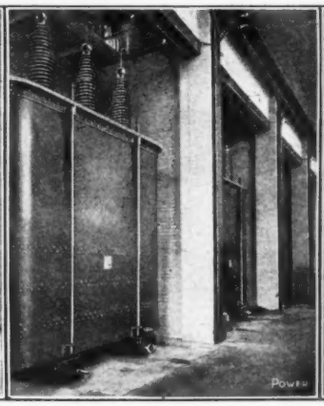


FIG. 14. 6000-KV.-A. TRANSFORMERS

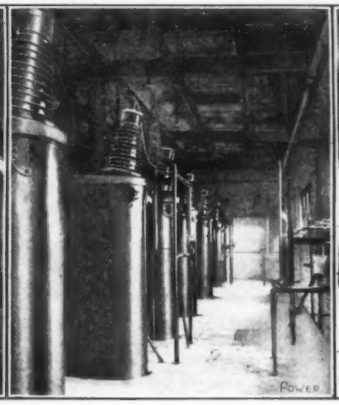


FIG. 15. SINGLE-PHASE TRANSFORMERS

FIG. 16. OIL SWITCHES

At present there are four 6000-kw., water-cooled, three-phase transformers (Fig. 14) with 13,200-volt primaries and 88,000-volt secondaries, together with the various regulating and controlling devices, consisting of 21 oil switches, all remote control, and 12 lightning arresters on a balcony over the transformers. The bus-bars are in concrete isolated compartments; the transformers are on trucks and can be rolled out of their bays if it becomes necessary.

The low-tension, 13,200-volt inlet lines enter the house 15 ft. above the main floor; the high-tension 88,000-volt outlet lines are 59½ ft. above the floor. The transformers are delta connected on both sides. Figs. 15, 16 and 17 show oil switches, single-phase transformer, and the switchboard of the transformer station. The latter is on the ground floor.

From the transformer house there are three outgoing 88,000-volt lines. One extends to Switchback via Bluefield. The second goes direct to Roanoke, but there is a branch from this line near Pulaski going through Pulaski and on to Bluefield and Switchback. This provides a double circuit into Switchback. The third high-tension line runs direct to Saltville. There is also a high-tension line connecting the Switchback and the Coalwood substations.

In addition there are three 13,200-volt transmission lines outgoing from the transformer house, one direct to Galax, one to Wytheville and on the same poles with the first of the higher tension lines, and one to Hiwassee, mounted on the same poles as the second of the higher tension lines.

MECHANICAL EQUIPMENT OF NOS. 2 AND 4 PLANTS OF THE APPALACHIAN POWER CO.

No.	Equipment	Make	Purpose	Kw.	Volts	Amp.	Phase	Cycles	R.p.m.	Hp.	Size	Manufacturers
4	Water wheels	Francis	Main units	..	....	..	...	..	116	3500	....	I. P. Morris Co.
3				..	....	..	...	..	97	3000	....	
2			Exciter units	..	....	..	...	..	360	430	....	
2				..	....	..	...	..	330	250	....	
4	Generators	Alt. current	Main units	4000	13,200	..	3	60	116	..	....	General Electric Co.
3				2300	13,200	..	3	60	97	..	....	
2		Direct current	Exciter units	250	250	1000	...	..	360	..	....	
2				250	250	600	...	..	330	..	....	
7	Governors	Hydraulic	Main units	..	....	..	...	..	...	..	....	Lombard Governor Co.
4			Exciter units	..	....	..	...	..	...	..	....	
4	Pumps	Plunger	Oil	..	....	..	...	..	...	..	....	Deane Steam Pump Co.
4	Motors	Induction	Oil pumps	..	220	70	6	60	845	25	....	Westinghouse Electric and Mfg. Co.
2	Compressors	Motor driven	Compressed air	..	....	..	...	..	....	..	7¼x¼x6″	Ingersoll-Rand Co.
2	Motors	Induction	Air compressors	..	220	26	6	60	1145	10	....	General Electric Co.

FIG. 17. SUBSTATION SWITCHBOARD

The company has a large distribution system in the Pocahontas coal fields radiating from the Switchback and the Coalwood substations. There a number of contracts have been made with collieries to provide power for their coal-mining operations. This is probably the first instance where a water-power development has supplied power to coal mines.

The company also operates the utilities in the towns of Marion, Wytheville, Pulaski, Bluefield, Pocahontas,

Welch and Keystone. It also sells power to the Roanoke Railway & Light Co.

In addition to the hydro-electric plants there is a 7500-hp. steam plant at Switchback, W. Va., which has been leased by the company, and will be used as a reserve station and to supplement the power from the hydraulic developments. This steam reserve will be in addition to that available from the various steam plants of the utilities purchased by the power company, and also to the steam power available from the steam plant of the Roanoke Ry. & Light Co. The map, Fig. 18, shows the water power, transmission line and district served by these hydro-electric developments.

Viele, Blackwell & Buck, of New York City, are the consulting engineers; and built the hydraulic developments and the high-tension transmission lines and substations. H. M. Byllesby & Co., of Chicago, are the engineers and managers of the company and built all the low-tension distribution system in the coal field and in the different towns which are now being supplied by the company.

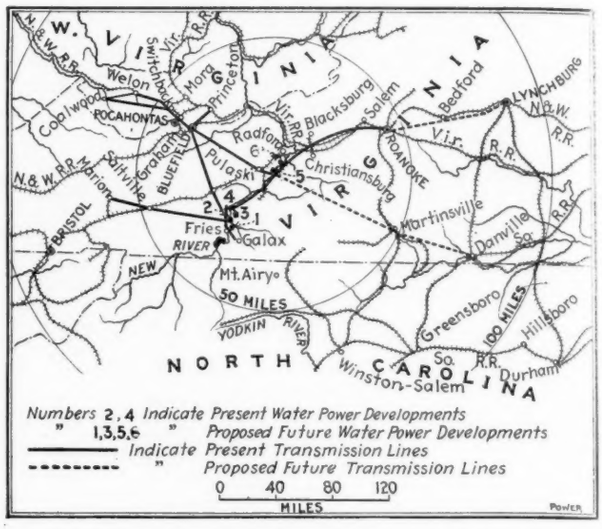


FIG. 18. MAP SHOWING POWER PLANTS, TRANSMISSION LINES AND DISTRICTS SERVED

How Many Boilers to Operate

BY G. B. MULLOY*

SYNOPSIS—When the rate of feed is known, the chart gives the number of boilers to be operated at full rating as desired.

In Armour & Co.'s Chicago plant, at the Union Stock Yards, the steam for power and factory purposes is generated by thirty-two 375-hp. Wickes vertical boilers. A three-stage Allis-Chalmers centrifugal pump, having a rated capacity of 1200 gal. per min. and direct-connected to a Kerr turbine discharges the feed water through an 8x4-in. extra-heavy Venturi tube. The flow through the latter is registered by a type "M" indicator and recorder.

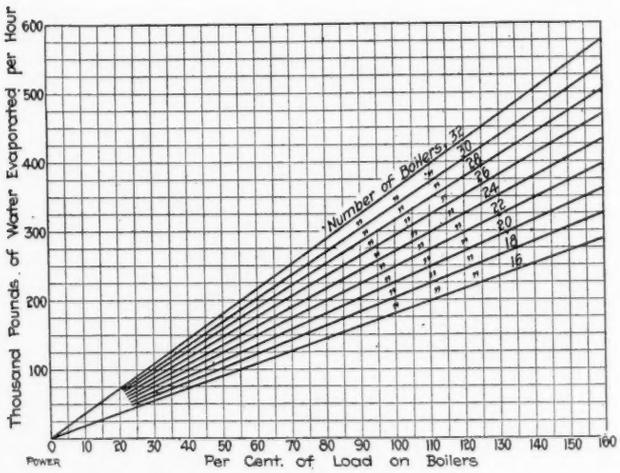


CHART SHOWING NUMBER OF BOILERS TO OPERATE

The fact that this instrument is arranged to indicate instantaneous flow as well as graphically record the fluctuations in the load carried throughout the 24 hr. makes it a desirable form of meter.

Due to the absence of any mechanism or projection within the Venturi tube the flow of water is unobstructed and this is desirable in any method of boiler feeding. From a curve which is supplied with each meter a correction factor enables the observer to determine the correct flow throughout a wide range of temperatures.

Not long after the installation of the meter the value of the data yielded was better recognized and extensive use was made of it. Previously there had existed no means of accurately determining just how many boilers were required to carry the load or within what per cent. of rating the boilers singly or collectively were working. Under ordinary conditions there is a certain load with which the best results are obtained from any given boiler and when it so happens that the steam for a given plant is generated by a battery of the same design, rating and furnace setting, only enough boilers should be in service at any one time to handle the load in the most efficient manner.

For this reason the chart herewith shown was developed, the interpretation of which is as follows: The ordinates represent pounds of water evaporated per hour, the abscissas the per cent. of normal rating developed and the diagonal lines the number of boilers required to satisfy the above variables. Assuming from a series of tests made on the test boiler that 20 per cent. overload is the most efficient operating load, the chart shows that for a flow of 300,000 lb. per hr., as indicated by the meter, 22 boilers are required. For normal rating 27 boilers would be needed or if the entire 32 boilers were used they would develop 83.5 per cent. of their rated capacity, assuming, of course, that each boiler was doing its share of the work.

So simple is the chart that it indicates at a glance at just what rating the boilers, considered as a unit, are operating, when the number in service and the rate of feed are known. It may be assumed without question that the results developed with the test boiler are generally never

*Engineer of tests for Armour & Co.

attained with each and every boiler in any one plant. The firemen naturally will show to their best advantage while on "dress parade." What they do as a regular thing in their ordinary task of firing is another story. But, by keeping a close watch on the coal pile, conditions of fires, etc., and constantly using the accompanying chart, it is possible to operate any boiler equipment so as to come within a close fraction of test conditions. Operating with the correct number of boilers for any given load will help to reduce to the minimum the cost of generating a unit quantity of steam, because the lower such items as labor, furnace and boiler repairs, radiation, loss of fuel through the grates, etc., are kept, the lower the unit cost of power will be.

CO_2 Diagrams from Actual Practice

By A. Bement*

SYNOPSIS—A number of interesting cases in which the results of analysis are connected with the performance of the fire. From the results improved methods of firing were introduced and the system was used as a check on the firemen.

The difficulty experienced by the average man is inability to connect the results of analysis of flue gases with the performance of the fire. It is of no use to him to know that CO_2 is low or that air is in large excess unless he knows how to correct the condition, and it is only by establishing a very direct and close connection between the performance of the fire and the indications of the analysis that a proper understanding may be obtained. The Orsat apparatus is a comparatively simple and low-priced device. Its disadvantage is, for the purpose in question, that it is slow, and before the engineer can get the result the condition has changed; or that he is so closely engaged in getting the sample and analyzing it, that he does not observe furnace conditions, and for this reason the combustion performance is not "caught in the act."

My experience began with the indication of CO_2 employing an Econometer, a device which indicated immediately the per cent. of CO_2 in the gases. Familiarity with this instrument and with the CO_2 determination before making use of an Orsat gave me a knowledge of the process, which never would have been acquired with the Orsat apparatus. I soon learned to watch furnace conditions, making this the main thing, and the reading of CO_2 accessory to it. For example, the condition, which might have been the cleaning of a fire, was noted, the time written down and observations made at one- or two-minute intervals of the CO_2 produced. Afterward these data were used in the preparation of a diagram, using per cent. of CO_2 as the vertical and time as the horizontal scale. This gave a diagram in many respects similar to the indicator diagram from an engine, and one which could be intelligently read, provided it was accompanied by some simple explanation, as given in the examples following:

Fig. 1 shows in condition *A* that the fire needed cleaning; that it was dirty was known, as it had not been cleaned for a considerable period. Now, as there was a considerable quantity of incandescent coal on the grate, it counld not follow that the air supply was not sufficient. The real reason was that the entrance for air through the fuel bed was obstructed, so that the coal while plenty of it was present, burned slowly; but the natural leakage of air into the furnace was just as large as though there had been a brisk fire. A few minutes later condition *B* shows the improvement brought about by cleaning the fire; that these two conditions were, as is described, is shown by the following analysis with the Orsat apparatus.

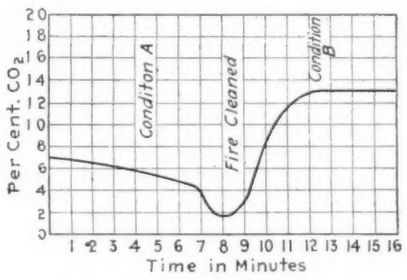


Fig. 1. Two Conditions of Combustion

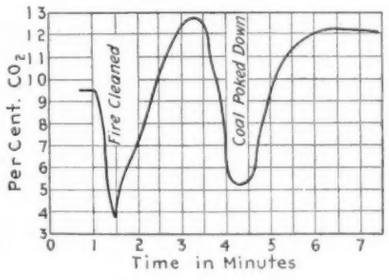


Fig. 2. Diagram from Acme Stoker

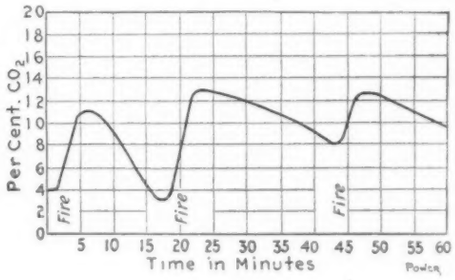


Fig. 3. Hand Firing

Conditions of Fire	*A* Dirty	*B* Clean
CO_2	6.5	13.0
CO	2.5	0.0
O	7.5	6.0

Thus it is apparent that one knowing from observation the conditions at *A* and *B* could immediately interpret the curve or diagram, and this method followed in all cases will make each example perfectly clear.

The remarks applying to Fig. 1 are also clearly illustrated in Fig. 2. This diagram is from a sloping grate stoker, with a dump grate at the bottom. Beginning with 9.5 per cent. CO_2 the fire was cleaned, with the result that the CO_2 immediately dropped to 3.7 per cent., recovering directly, however, when the dump grate was closed, and facilitated also by the fact that the firemen poked down out of the hopper on to the stoker grate a large quantity of fresh coal. The CO_2 rose to 12.7 per cent., after which it rapidly declined to 5.3 and soon recovered to a little over 12 per cent.

In this digaram there are two serious drops in CO_2. The first one was due to excessive air, but with fuel in

*Consulting engineer, 29 South La Salle St., Chicago.

excess the second drop was due to an enormous volatilization from the coal, and instead of the carbon having a chance to enter into combination with oxygen it flowed away in great masses of smoke. This conclusion is verified by the fact that when this excessive fuel had burned down to normal condition the CO_2 rose above 12 per cent. Before the CO_2 determination was employed, it was thought that this excessive poking down of coal after cleaning was a desirable thing. After the facts were discovered, practice was so corrected that CO_2 rose immediately after cleaning the fire and proceeded at the maximum, the second drop being entirely absent.

Fig. 3 shows results from hand firing typical of usual good practice. The rise of CO_2 accompanying the application of fresh coal is distinctly shown to a certain point, after which as the fire burns away it drops. In this case the second firing is seen to be better than the first one, because the CO_2 goes higher and continues longer. From this performance one may readily study the best method for hand firing.

Results of hand firing where the fuel bed was in a very open condition, allowing excessive air to flow through it, are shown in Fig. 4. At the interval when CO_2 began to increase, the fire was leveled with a rake and the openings closed. The air supply was more thoroughly employed and the CO_2 increased from 4.5 to 14.5, gradually dropping as the coal burned away.

Examples of the work of two different firemen are shown in Fig. 5. The furnace was large with six doors to be fired by hand. It was observed that whenever fireman A added coal the CO_2 dropped slightly because he dumped the coal with little or no care. Previous to the making of this diagram, it was not realized that there was anything wrong with his method. Fireman B, however, broke his coal properly and spread it carefully, with the result that a rise in CO_2 immediately followed each firing. As the furnace was large the firing was continuous, with slight intervals between shovels but with no decided intervals between firings.

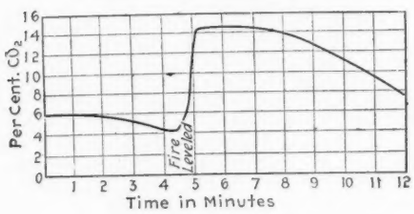


FIG. 4. EFFECT OF LEVELING FIRE

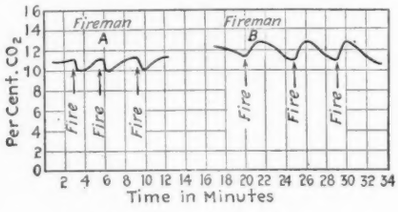


FIG. 5. DIFFERENT KINDS OF HAND FIRING

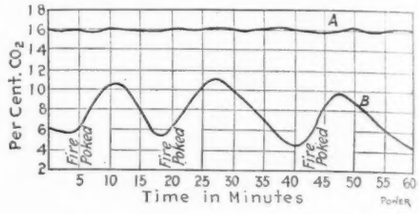


FIG. 6. FIRING IN HAWLEY FURNACE

Fig. 6 shows two curves taken from a Hawley furnace. Curve *B* shows the performance which habitually prevailed when the men were especially careful. The rises in CO_2 followed poking the fire on the upper grate. The practice was to poke down a certain amount of coal from the upper grate and allow it to burn in a pile upon the lower one, with only an indifferent leveling of the lower fire. Thus it appears that as the fire was poked, CO_2 rose, and as the fire on the upper grate became compact again and the fire on the lower grate burned away, CO_2 fell, to rise again at the next poking which was at a considerable interval. As it was apparent that when the fire was poked and the bottom grate leveled CO_2 rose, it would appear that a continual poking and a continual leveling would remedy the condition.

Therefore, in the experiments, the fireman devoted his entire time to poking the fire of the upper grate and to keeping that on the lower grate level and clean. The result was that the boiler, which had 3500 sq.ft. of heating surface and 120 sq.ft. of grate surface, half of which was in the upper grate and the rest in the lower, produced 850 hp. The labor was beyond the continual endurance of one man, so the draft was reduced and the coal-burning capacity brought down to the ability of the man. At this point proper manipulation gave the efficient performance indicated by curve **A**, which is in marked contrast to previous practice shown by curve *B*.

Some typical examples of the results due to the time taken in cleaning fires in the Hawley furnace are shown in Fig. 7. The first diagram, showing a large drop, represents a condition with which no one found fault until a CO_2 diagram had been made. The second diagram shows what was readily attainable after a little experience.

Fig. 8 illustrates a serious trouble. The plant was equipped with Hawley furnaces and screenings had been used, the fuel bed being about 8 in. deep. In an emergency it was necessary to use lump coal. The men being familiar with an 8-in. fire followed that practice with

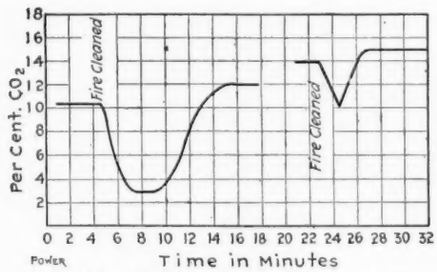


FIG. 7. CLEANING FIRES IN HAWLEY FURNACE

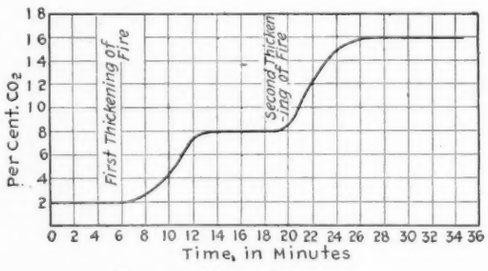


FIG. 8. LARGE COAL AND EXCESS AIR

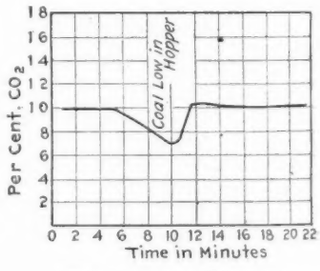


FIG. 9. COAL LOW IN HOPPER OF CHAIN GRATE

the lump coal. As only the edges of the lump came together, large spaces were left for the flow of air, and this air was in such excess that nearly all the heat went up the chimney and there was little or none available for making steam. An inspection of the fires did not reveal the difficulty, as the coal burned rapidly, the fire roared and the men were shoveling in lots of coal. No one thought to look at the Econometer, which was in operation, and the trouble man was sent for. Upon his arrival he looked at the instrument and saw only 2 per cent. of CO_2, which suggested excess air. A glimpse at the fire confirmed this. He ordered the fireman to "fill up the furnace, pile it full of coal." As he began to add the coal, CO_2 increased. After the fireman had put in coal enough to make the fuel bed about twice as thick, CO_2 went to 8 per cent. At this point the fireman seemed satisfied, but was told to again fill up the furnace. He shoveled it entirely full, and the result was an increase of CO_2 from the point marked "second thickening of fire" to 16 per cent. When this had been done, the fireman sat down for an hour and watched it burn, and with this and the other thick fires steam was made in abundance.

A drop in CO_2, caused by letting the fuel in the hopper of a chain-grate stoker get low, is shown in Fig. 9. Many firemen think that it does no harm to let the fuel get low in the hopper, provided it does not get below the gate. This diagram shows the result of the coal being only a little way below the top. The CO_2 dropped from

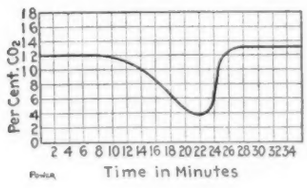


FIG. 10. SHORT FIRE WITH A CHAIN GRATE

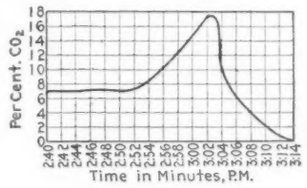


FIG. 11. AN EMERGENCY CURVE

10 down to 7 per cent. and rose again as soon as the hopper was filled. Fig. 10 shows the result of allowing the fire to get short on a chain grate, and illustrates its recovery when the fireman "winds up" the grate.

Fig. 11 shows the advantage of sometimes being able to ascertain what has occurred in a past emergency. The plant from which this diagram was made was new and equipped with a CO_2 recorder. Trouble had been experienced from bridge-walls collapsing and a number of repairs had been made without knowing the cause. One day the CO_2 machine happened to be connected with one of the boilers during the time that a bridge-wall failed. When the expert arrived to look into the trouble he asked at what time the trouble occurred and was told that the boiler was taken off immediately after three o'clock. Consulting the record shown in the diagram, it was apparent that CO_2 had risen to a high point a few minutes after three o'clock.

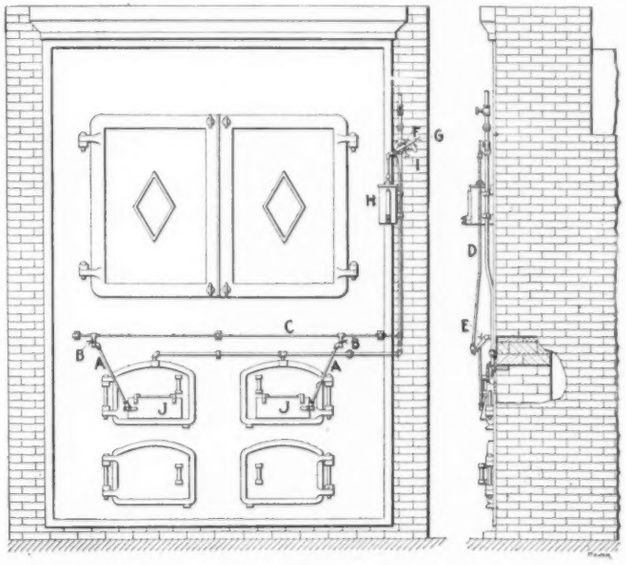
As a very high CO_2 indicates very high temperature, this evidence suggested that temperature may have played a part in the failure. An investigation showed that the interior of the bridge-wall contained common brick and was faced with firebrick. When an unusually good combination in size of coal entered the fire, CO_2 and temperature rose to a high point, with the result that the common brick melted and ran out of the wall, allowing the firebrick to collapse.

A plant equipped some years ago with Hawley furnaces made use of an Econometer to which a recording device had been attached. From each of the furnaces a pipe led to a header located at the instrument. Each one of these pipes had a stop-cock in it, so that any one of them could be cut in on the instrument. Experience showed that while the firemen were being watched they did much better work than when they were not. When the making of a record of CO_2 began, the men would look at the header to see what furnace was cut in and after they had discovered it, that one would receive special attention; the header was then so covered that they could not see which line was in use. Their next move to "beat the machine" was to take each furnace in series and do something abnormal with it while the instrument was carefully watched. In this way they again located the furnace from which the record was being made. The next step then was to cover up the front of the instrument so that they could not see it, with the result that a decided improvement in economy was secured.

Another example of the use of the instrument occurred in a plant which was equipped with a long row of boilers served by chain-grate stokers. The foreman whose office was in a little inclosed building carried a pipe along the whole battery, with branches to each furnace. This pipe ran behind the setting and in such a way that the firemen did not have access to it. When the foreman became suspicious of the workmanship of a fireman, he would cut on the furnace to the instrument, and when CO_2 fell he would walk back to the man, look into his furnace and call his attention to a short fire or some other condition. In this way he was able to immediately locate trouble.

Scharf Smoke Prevention System

The accompanying illustration shows the Scharf system of smoke prevention, based on the use of intermittent steam jets and automatic regulation of the air supplied over the fire. When one of the firedoors is opened the



BOILER EQUIPPED WITH SCHARF SMOKE-PREVENTING SYSTEM

rod *A*, connected to the arm *B* by a toggle joint, causes the shaft *C* to rotate part of a turn. This lifts the arm *E* and the vertical rod *D* and the lever *F*, hinged at *G*, is raised to a horizontal position. This action raises the plunger in the oil-filled dashpot *H* and the lever valve *I* in the supply pipe of the steam jets is opened.

When the furnace door is closed, the dashpot piston is released, which then commences to sink to its original position. It also opens the half doors *J*, permitting an ample supply of air to enter the furnace over the fire. When the piston reaches its lowest position the half doors are closed once more and the steam jets are completely shut off.

The time required for this operation can be varied to suit firing conditions by adjusting the bypass valve which controls the flow of oil from the under to the upper side of the piston.

This system is manufactured by the Power Efficiency Corporation, Detroit, Mich.

Large Producer Gas Plant

The Canadian Car & Foundry Co., Fort William, Ont., has recently installed three 600-kw., 60-cycle, three-phase, 500-volt, alternating-current generators which will be driven by producer-gas engines. It is claimed that this will be the largest producer-gas plant in Canada. The engines are of the single-tandem, horizontal, double-acting, four-cycle type, with cylinders 28x36 in. and operating at 150 r.p.m.

The main gas plant consists of four double bituminous coal generator sets, and was originally intended for heating purposes, but as it is necessary to intermittently change from the water-gas operations to producer gas, it was decided to utilize the waste, or producer gas, for power purposes. This gas will contain more than 10 per cent. hydrogen by volume and is particularly suitable for use in gas engines.

The fuel gas, which will be used for furnace work, will have a heat value of 300 B.t.u. per cu.ft. and will contain about equal parts of hydrogen and carbon monoxide. The operation of the producers will be such that it will be practically impossible to mix the gases; that is, the regulation of the gas will be automatic, eliminating any liability of water gas being carried to the engines. In the use of double generating sets the gas is drawn off the top of one generator and down through the incandescent coal mass of the other, the tar being consumed and converted into gas, thereby increasing the efficiency of the plant. The resulting deposits of soot will be disposed of through a Thiesen washer.—*Electrical News.*

New Wheeler-Balcke Natural Draft Tower

In locations where condensing water is scarce, a properly designed cooling tower becomes equivalent to a natural water supply. If it operates with natural draft and no fan is used, the chief item of operating expense is the cost of lifting the water to the distributing system. The primary essentials for effective cooling are large capacity for dissipating heat to the atmosphere so that a large volume of water is cooled, and ability to dissipate this heat at a low temperature so that the water may be cooled as much as possible. To accomplish this, the water must present an extensive cooling surface to the air rising within the tower, and, secondly, there must be a brisk and vigorous air circulation.

In the new Wheeler-Balcke natural-draft chimney-type tower, illustrated herewith, the cooling is done on the "drop and film" principle. The cooling stacks are arranged in zigzag tiers which offer little resistance to the upward flow of the air. The cooling laths retard the downward flow of the water, spread it out into thin films and break it up into drops. Fig. 1 shows the construction of the tower. At the top is the vapor outlet, beneath

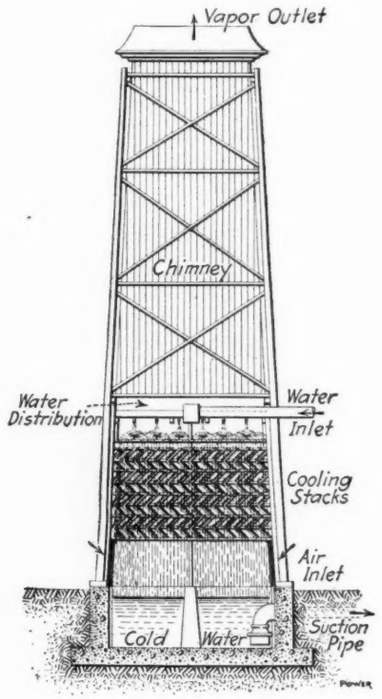


FIG. 1. TYPICAL LAYOUT OF COOLING TOWER

is the chimney, and next the water-distributing system which receives the water to be cooled from the water-inlet pipe and discharges it over the whole surface of the tower. Immediately below the distributing system are the cooling stacks and the air inlets, and at the lowest point is the cold-water well in which the water is collected and drawn off to the condenser.

The chimney and vapor outlet are of cypress boards supported by a framework of yellow pine, both woods being specially treated to prevent deterioration. The main trough into which the water is discharged from the inlet is of cypress planks 1½ in. thick. From this trough the water flows into lateral gutters, which in turn distribute it over the entire area of the tower by means of iron pipes arranged at equal intervals in the length of the gutters. The water falling from these pipes impinges upon galvanized-steel splash plates which break it up into a fine spray. In the form of spray the water then drops upon the triangular cooling laths below, which are arranged in zigzag tiers, as shown in the accompanying drawing. The zigzag arrangement insures the breaking up and turning over of the water without presenting high resistance to the rising column of air. The comparative space occupied by the cooling stacks and the location of the air inlet is apparent in the drawing.

In large towers the multicellular design, shown in Fig. 2, is used. Owing to the resistance of the falling shower of water, air will not penetrate to the center of the large tower, and the water in that region will not be cooled as efficiently as that falling in other parts nearer the shell. With the multicellular design, air is evenly distributed

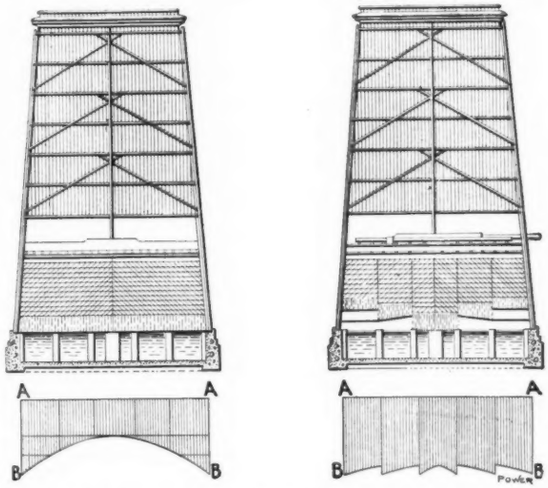


FIG. 2. MULTICELLULAR TOWER WITH TEMPERATURE DIAGRAMS BELOW

to all parts of the tower, and the water in the center is cooled to practically as low a temperature as the water near the shell. The diagrams below the illustrations of the tower demonstrate this point. Here the line *AA* represents the temperature of the water entering the tower and *BB* represents the temperature of the water at various points in the cross-section of the tower as it falls from the cooling stack. In the multicellular design, it will be noticed that the temperature of the water as it is discharged is nearly uniform, while in the single tower the

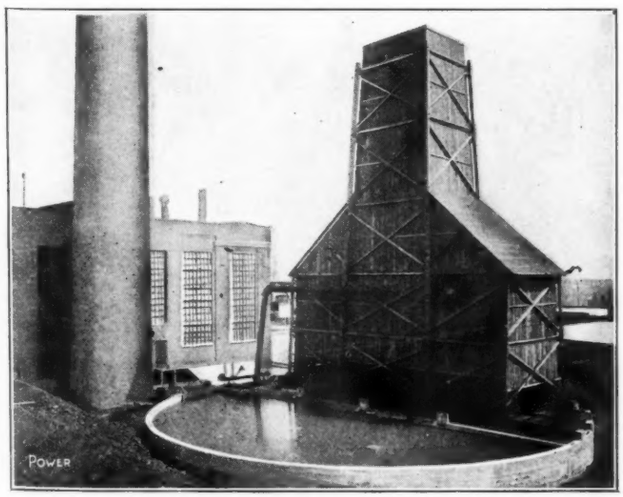


FIG. 3. WHEELER-BALCKE TOWER INSTALLED AT PLANO WORKS OF INTERNATIONAL HARVESTER CO.

temperature of the water at the center is considerably higher than at the sides.

Fig. 3 shows a tower of 72,000 gal. per hr. cooling capacity installed at the Plano Works of the International Harvester Co., West Pullman, Ill. As may be seen, the tower is erected over a concrete reservoir, which is large enough for a second tower of equal size. The reservoir is 75 ft. in diameter and has a capacity of 600,000 gal., forming a large, cold well and also a reserve supply of water for the fire pumps. The cooling tower operates in connection with two jet condensers. The tail pumps discharge directly to the distributors of the cooling tower through the pipe, which may be clearly seen in Fig. 3. The elevation of the distributors may be estimated from the height of this pipe. The base of the tower is somewhat above the elevation of the turbine-room floor and is at a considerably higher elevation than the condensers, which are in the basement beneath the turbine. Flooding of the condensers in case of failure of the vacuum is prevented by siphons in the suction lines.

RESULT OF TESTS OF COOLING TOWER AT INTERNATIONAL HARVESTER CO.'S WEST PULLMAN PLANT

Test No.	Date 1912 Sept.	Gal. per Min.	Water Temp. In	Water Temp. Out	Air Temp. In	Air Temp. Out	Air Humidity In	Air Humidity Out	Weather
2	11	1230	112	87	71	99	69	100	Strong wind, cloudy
3	11	1230	112	85	71	102	56	100	Strong wind, cloudy
4	11	1230	111	86	69	96	64	100	Strong wind, cloudy
5	12	1230	105	83	71	93	56	100	Light breeze, clear
6	12	1230	106	81	74	95	56	100	Light breeze, clear
7	12	1230	106	82	77	97	49	100	Brisk breeze, clear
8	12	1230	106	82	78	96	49	100	Brisk breeze, cloudy
9	13	1200	102	82	74	91	47	100	Light breeze, clear
10	13	1200	103	81	75	93	47	100	Light breeze, clear
11	16	2100	97	83	65	92	73	100	Light wind, clear
12	16	1700	101	83	68	95	62	100	Light wind, clear
13	16	1520	104	85	72	94	57	100	Light wind, cloudy
14	16	1520	104	85	70	95	68	100	Light wind, cloudy
15	17	1620	99	82	63	92	84	100	No breeze, cloudy
16	17	1280	106	82	63	96	84	100	No breeze, cloudy

The accompanying table is a summary of a number of tests conducted on this tower. It may be noticed that the air leaves the tower fully saturated. Tests 15 and 16 can be selected as showing the efficiency with which cooling is secured, even with high humidity of entering air. In each of the two cases cited the humidity was 84 per cent., the temperature of the air being 63. In test 15 the cooling was from 99 to 82 deg., and in test 16, from 106 to 82 deg.

About two weeks later, on a moderately warm but dry afternoon, the tower was supplying ejection water at about 72 deg. temperature and the vacuum on the turbine was slightly lower than 28 in. In a general way, this shows the possibilities of the tower during the summer. In the colder months of the year it will be evident that vacuums above 28 in. may be obtained.

A Small Office Building Plant

The Buffalo Natural Gas Fuel Co. is erecting a building at the northeast corner of Franklin and Church Sts. This building will generate its own electric current, and as it will be one of the smallest buildings on record to do this, the experiment will be worth watching.

The power plant will be a demonstration of the possibilities of a natural-gas engine, and will consist of three units of 150 hp. each. The electricity thus generated will run the refrigerating machinery, the house and fire pumps, the vacuum cleaner, the elevators and the auxiliaries. Supplementing this will be a storage battery which will help over the peak load and will be capable of running two hundred 25-watt lamps for eight hours.

This plant will occupy the sub-basement and will be so arranged that visitors may see the operation of the engines from the basement showrooms. The owning company will occupy the first and second floors, and basement, and the balance of the building will be rented.

ELECTRICAL DEPARTMENT

Remote Control through Street Mains

By Arthur H. Allen

An interesting method of remote control has been developed by W. Duddell, president of the Institution of Electrical Engineers, and Messrs. Handcock & Dykes, consulting electrical engineers, of London. It is intended to permit street lamps to be lighted and extinguished, two-rate meters to be controlled, etc., from the power house or substation, without any other means of transmission than the distributing mains themselves. It will readily be seen that such a system makes it possible to supply street and shop-front lamps from the ordinary mains, the customary method in England, and yet to switch them on and off at any desired time without using pilot leads or employing a number of lamplighters. Special systems of charging for electrical energy can also be adopted, such as that in which the rate of registration of a meter is accelerated during the time of heavy demand, and retarded during the daytime, dispensing with the use of two meters or a two-rate meter.

The principle of the invention is simply that of superposing upon the main supply current an auxiliary current of a different frequency, to which suitable relays respond at the points where the lamps, meters, etc., are situated. In the case of a direct-current supply the problem is easily solved; the relay is placed in shunt across the mains, with a condenser in series with it. No current passes through the relay circuit under normal conditions, but when an alternating current is injected into the direct-current supply, as, for instance, by cutting in a small alternating-current generator in series with the mains, the alternating current flows through the relay circuit and actuates the mechanism, which closes a switch or performs any other desired operation in a manner familiar to electricians.

Where the supply is alternating, the matter is not so simple. In this case the relay must be selective, responding only to a particular frequency, and this result is obtained by correctly proportioning the inductance and capacity of the relay circuit so as to produce resonance at the said frequency. In passing, it may be pointed out that selective relays are useful also on a direct-current supply, as they may be tuned to different frequencies, to effect different purposes. A large number of different frequencies may be employed, and the facility of tuning is such that a potential difference at the terminals of the relay may thus be obtained which is ten times that of the supply circuit, so that there is no risk of the relay being actuated at any time except the appointed moment. Where the supply is alternating, the inventors find it desirable to use frequencies comprised between the third and fifth harmonics of the supply frequency, and a superposed voltage about 5 per cent. of the supply voltage. There is no appreciable interference between the superposed current and the normal current, owing to the difference in frequency, the former being merely a ripple.

In practice it is found that the simple relay and condenser circuit, K and L, Fig. 1, while satisfactory on a direct-current system, does not afford sufficient margin for adjustment on alternating-current circuits. If the tuning is sharp, so as to prevent operation by the normal frequency of the circuit, a slight variation in the frequency of the superposed current will result in failure to operate, while if the tuning is not sharp, the relay may operate with the supply frequency. To overcome this difficulty, a second winding L_1 is applied to the relay, in circuit with a choke coil L_2. The current in the latter circuit is nearly 180 deg. out of phase with that in the normal relay winding, and practically neutralizes the effect of the normal supply current, leaving the resonance current master of the situation. A compensated relay of this kind operates with certainty at 5 volts, 200 cycles, on a supply circuit at 100 volts, 50 cycles, and even if the supply voltage is increased by 100 per cent. the relay is not affected. Moreover, the frequency of the superposed current can be varied 5 per cent. up or down without causing failure to operate. The power absorbed by the relay at 100 volts, 50 cycles, is only 0.7 watt, from the normal supply, and the same power, at 5 volts, 200 cycles, is sufficient to cause it to operate. To send the ripple over the mains, a small alternating-current generator can be cut into circuit, or it can be coupled to the primary of a transformer, the secondary of which is in circuit with the mains. The frequency of the generator can, of course, be varied according to the particular set of relays that it is desired to operate, and obviously the relays can be wound and the condensers chosen to suit any ordinary supply voltage and frequency. The coils L and L_1 on the relay can also be combined, as they are in Fig. 2.

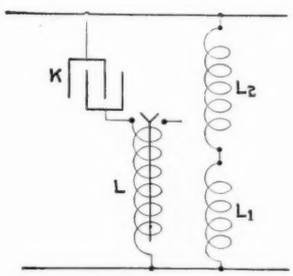


Fig. 1.

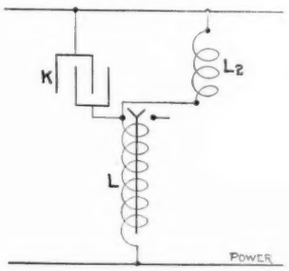


Fig. 2.

Relays and Choke Coils for Remote Control

In addition to the lighting and meter applications already mentioned, there are many other uses for this remote control system. Transformers in substations can be switched on and off whenever desired, the circuits of consumers who pay by contract for a fixed daily period of service can be cut in and out, time signals can be given to enable consumers to set their clocks right at specified hours, electric track signaling on alternating-current railways can be effected, etc.

Largest Direct Current Generators

The largest direct-current generators ever built have just been installed in the Canal Road plant of the Cleveland Electric Illuminating Co. There are two 3750-kw., 275-volt, shunt-wound machines, driven at 180 r.p.m., through 10 to 1 Westinghouse reduction gears by steam turbines. Fig. 1 shows the generator on the erecting floor in the Westinghouse shops, while Fig. 2 is a view of one of the units after being installed. The former view

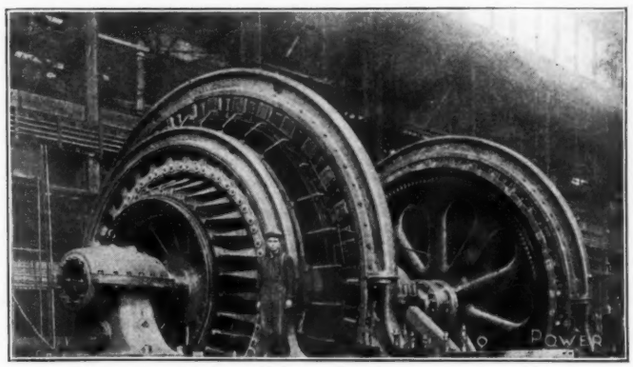


FIG. 1. GENERATORS ON ERECTING FLOOR

gives an idea of the size of these machines by comparison with a man of ordinary height standing beside them.

The large gear of the speed-reduction mechanism, Fig. 3, is 100 in. in diameter and has 259 teeth. The pinion has 26 teeth and a speed of approximately 54 miles an hour is attained at the pitch line. At full rated load of the generator the gear transmits over 5000 hp. and, on several occasions during overloads, has carried 6000 hp.

These two machines will supply light and power to the business section of Cleveland. The company's system was originally three-wire Edison but, as the business increased, alternating current was distributed to the outlying districts. The downtown business district, however, was never changed and is still fed from a three-wire system. The company also furnishes steam heat to this district.

When the new Lakeshore plant (see description in Mar. 18 issue) was designed, it was decided to let this supply

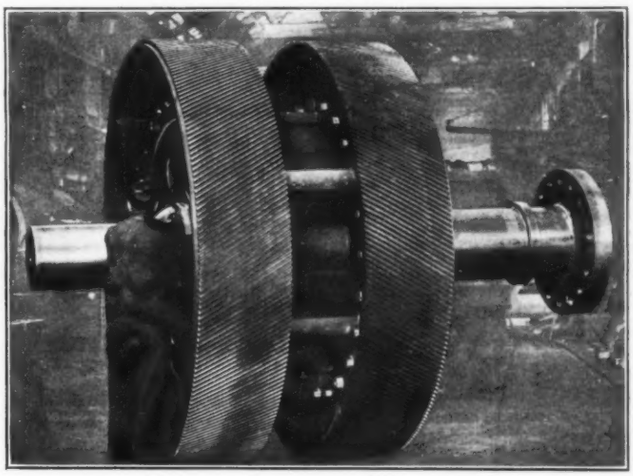


FIG. 3. LARGE GEAR

the alternating current and have the Canal Road plant a strictly direct-current station. A consideration which largely determined this was the fact that the Lakeshore plant is nearly four miles from the business center, while the Canal Road plant is only a few blocks away; hence, the ability of the latter to supply exhaust steam for heating.

It is the intention of the company to run these direct-current generators only during the months in which exhaust steam is required for heating, the Lakeshore station supplying the three-wire system through rotary converters during the other months.

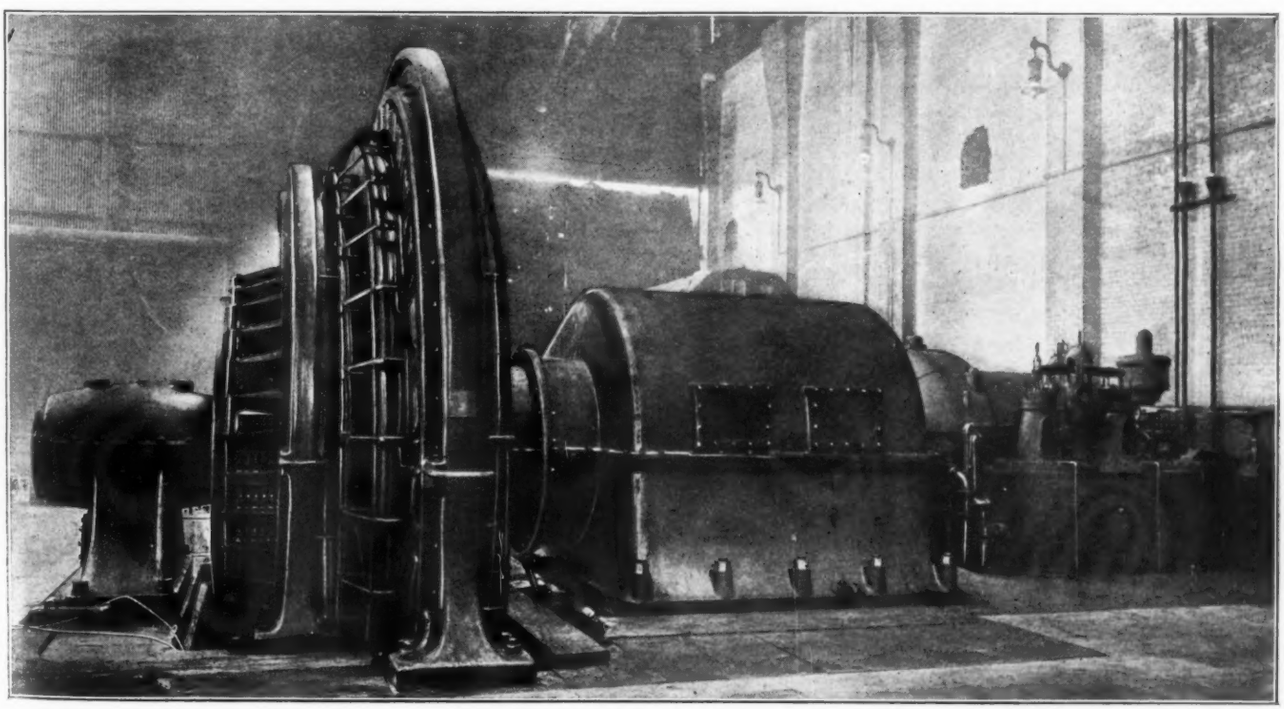


FIG. 2. UNIT FROM GENERATOR END

Rotary Converter without Shunt Field

Mr. Hill's question in the Feb. 20 issue of POWER, as to what would happen if a loaded rotary converter should lose its shunt field, is rather indefinite, as he fails to state the type of machine and the conditions under which it was operating, which would produce widely varying results.

In one instance, I was dusting the switchboard and the cloth caught on the field switch and opened it. Two 100-kw. machines were carrying the load and the station was running in parallel with a number of others on the same system, the nearest being about half a mile away. The two machines were connected in series on a three-wire system and were carrying about 25 per cent. load; the fields were very weak. When the field switch was opened, the machines dropped very little of the load and the voltage remained practically normal, as there was no indication of the trouble on the recording voltmeters.

The second case happened with a 500-kw., six-phase machine, running alone and carrying about 75 per cent. load. The station was practically isolated, being connected to the nearest station, over a mile away, by one small line. The connection between two of the field coils became loose and burned off, opening the field circuit. The machine then carried about 50 per cent. load with the induction regulator in full boost position, until we located the trouble. The power factor was below the range of the power-factor meter, which indicated as low as 50 per cent.

Another time one of the operators accidentally opened the field switch through his shirt sleeve getting caught on the switch. This was a 1000-kw., six-phase machine, running in parallel with four others of the same type and capacity. The opening of the field switch was accompanied by some fireworks at the commutator and the direct-current circuit-breakers opened from the reverse circuit relays. These operated to open the circuit-breakers when the reverse current became 50 per cent. of the normal full-load current.

In all these cases, the machines were single shunt-wound, with an induction regulator on the alternating-current side, and running on a three-wire, 230-volt Edison system.

The next time I saw this happen, was in a street-railway substation. This was a 1000-kw., six-phase, 600-volt, compound-wound machine, running in parallel with another of the same type and capacity. The operator, in trying to straighten a bent field connection, broke it off. Instantly, there was flashing and the circuit-breakers on both machines opened.

Another time, while starting from the alternating-current side, I forgot to close the shunt-field circuit after the machine was up to speed and after cutting in the machine picked up some load before I became aware of the fact. The machine was carrying about 10 per cent. load when I happened to notice the alternating-current ammeter showing about that much excess over full-load rating. The power-factor meter was out of order or I would have noticed the slip sooner. I reduced the load to zero again, the alternating-current ammeter then indicating about full-load current. Without making any further experiments, I closed the field switch and picked up the load.

From these two indications, it would seem that it takes about full-load current to run the machine and excite the fields and, from this point, the current increases at normal rate in proportion to the load. On this assumption, the power factor would vary from about 5 per cent. at no load to 50 per cent. at full load, provided it was possible to make the machine carry full load.

THOMAS G. THURSTON.

Chicago, Ill.

In the Feb. 25 issue, N. M. Hill asks what would happen if a rotary converter should lose its shunt field.

I had an experience some time ago, which might be of interest to Mr. Hill. Being called upon to investigate operating troubles on a 200-kw., 60-cycle, self-starting rotary converter for railway service, I was surprised to find that the converter had been operating for a month, or since its installation, without a shunt field. During installation the field switch had been wired incorrectly, leaving the shunt-field circuit entirely open on either position of the switch.

The converter was carrying loads up to 25 per cent. above its normal rating without the shunt field, but it was noted that it heated up more on no load, or light loads, than on full load, also it was noted that the alternating current supplied to the machine was just about the same whether the machine was delivering zero or full load on the direct-current side.

Unfortunately, there was no power-factor meter on this converter, but undoubtedly the power factor was down almost to zero on no load and light loads, improving as the direct-current load increased.

The magnetic flux required in the magnetic circuit of a rotary converter is produced by either of two sources: by current in the field windings or by current in the armature winding. When the exact amount of flux required by the machine is not provided by the field excitation, it is automatically provided by leading or lagging currents in the armature winding. The magnetizing effect of leading currents is to oppose the initial field flux, while that of lagging currents tends to assist the initial field flux; hence in the case under consideration, the field flux at no or light loads was produced almost entirely by heavy wattless lagging currents flowing in the armature, and this current would cause the low power factor and heating noted at no or light loads.

Had this rotary converter been of larger capacity as compared with the size of the generating units supplying the alternating current, it is probable that it would have caused such a disturbance on the system that the trouble would have been detected at once, or had the converter been working properly at the start, and then suddenly lost its shunt field while running, the difference in operating conditions would have been noticed at once from the alternating-current ammeter readings, the heating of the armature, and the failure of the machine to respond to the moving of the shunt-field rheostat handle.

Again, had the converter been of the plain shunt-wound type, without the assistance received from the series field turns when the direct-current load came on, it is quite likely that the armature would have been damaged from heating, since the wattless currents would have remained high even when the direct-current load was high, and the combination of the two would work the copper in the armature far beyond its capacity.

Elmhurst, L. I. S. A. LEWIS.

GAS POWER DEPARTMENT

The Junkers Engine—VIII

By F. E. Junge

In the concluding article of this series it remains to discuss such points as reliability of operation, overhauling, friction, and dismantling, and general economic aspects of the Junkers engine.

Pistons and Lubrication

The long cylinder of the Junkers engine is open at both ends, and the extreme sections of the cylinders are well away from the combustion chambers. Thus these parts may be kept comparatively cool, and as with every revolution the pistons enter these well cooled sections, a constant exchange of heat is maintained between the pistons and the cylinder walls. Moreover, the lubrication is more favorable the lower the temperatures of the lubricated parts and, owing to the subdivision of the stroke between two pistons the distance traversed per stroke is diminished, thus increasing the lubrication efficiency.

Cracks in Combustion Space

Cracks occurring in cylinder walls are to be attributed largely to the stowage of heat in these parts, occasioned by nonuniform disposal of the material, and the restriction of the free expansion of the castings. In the Junkers engine the combustion chamber is surrounded by a smooth cylindrical shell of even thickness. The ends are formed by simple flat piston bottoms which admit of a uniform distribution of the material. An unrestricted free expansion of these castings is thus insured. In the Diesel engine of normal design circumstances are decidedly less favorable. The cylindrical shell inclosing the combustion space is provided with a heavy flange for receiving the cylinder cover. This flange, in combination with the clamping effect of the cover, does not permit of unrestricted radial expansion of the cylinder. The cover with its valve casings constitutes a complicated casting, of uneven distribution of material, in which the local stowage of heat is inevitable. A free expansion of this securely fixed casting is impossible. These parts are thus very apt to develop cracks.

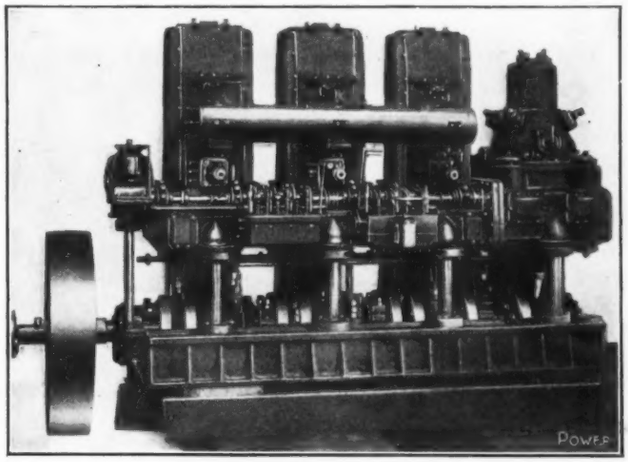
Valves

The Junkers engine possesses only a fuel injection valve and a compressed-air starting valve. These are of small dimensions and can be well controlled, as regards heating; undue heating of the valve springs cannot occur, since they are located far back from the cylinder. The valve-gear is simple and subject to little stress. After starting up with compressed air only the fuel injection valve-gear is kept permanently in operation.

On the other hand, in the normal Diesel engine, apart from the injection and starting valves, there are scavenging valves, fixed in the combustion chamber. With large engines these valves are heavy and as they have to be accelerated, retarded and again accelerated, within a fraction of a second, great stress is placed on the valve-gear. Moreover, the valves are all concentrated in the heated cylinder cover.

Overhauling, Erection and Dismantling

One of the chief demands with which a prime mover has to comply is provision for accessibility to those elements, which are most susceptible to wear, and to those parts which are most likely to get out of order and cause a breakdown. The overhauling and dismantling work connected with casual and periodic inspection must be done within the shortest time and by as few hands as possible. In an oil motor these inspections cover mainly the cylinders, pistons and valves, their seats and accessories. In this respect the Junkers engine offers great advantages, as those parts most susceptible to wear, the cylinders with their pistons and rings, are but slightly



150-hp. Junkers Engine

taxed, owing to the method of guiding, the relatively small piston speed and the good lubrication. Thus frequent inspection becomes unnecessary. If, however, such inspection should be required it may easily and speedily be accomplished by a few hands, since, for dismantling, only a few bolts have to be loosened. The fuel injection and starting valves are also easily inspected, the disconnecting of the valve-gear presenting little difficulty.

In the Diesel motors employing scavenging valves the seats of the latter and the valve disks require frequent attention, involving considerable labor, for one can get at these parts only by removing the heavy cylinder covers together with their complicated valve-gear.

Economic Considerations

The cost of production for a normal power unit depends mainly on the weight of the engine, and the wages paid for machining. Owing to the tandem arrangement of the Junkers engine, the interlocking of the forces in the driving mechanism, the high mean pressure, etc., the weight of the engine figures less than that of a normal two-stroke-cycle Diesel engine. Also the absence of in-

tricate castings and governing elements, and the simplicity of its parts make the machining costs less.

Life and Repairs

As already pointed out, the number of important parts given to wear are small, and delicate parts working permanently under high pressures and temperatures or other unfavorable conditions are absent; hence, the life of the engine may be considered long, whereas the running repairs and renewal costs may be considered small.

Efficiency and Fuel Consumption

Owing to the perfect utilization of the driving mechanism in the Junkers engine, the relief of the main bearings, the simple actuating of the pumps, the small throttling losses, etc., the mechanical efficiency is higher than that of the normal two-cycle Diesel engine, especially for large work; because in the case of the latter, large outputs are to be realized only by aggregating several single-cylinder units. The other favorable features in the Junkers engines pertaining to favorable heat transmission in the combustion chamber and excellent scavenging (pure and cold charge), insure complete combustion and a high thermal utilization of the supplied fuel energy. The fuel consumption is thus kept within reasonable limits.

The firms building Junkers engines on the European continent are: J. Frerichs & Co. A. G., Osterholz-Scharmbeck; "Weser" A. G., Bremen; Maschinenfabrik "Badenia," Weinheim; Maschinenbau Aktiengesellschaft vorm. Gebr. Klein, Dahlbruch; Ehrhardt & Sehmer, G.m. b. H., Saarbrücken; Allgemeine Elektrizitäts Gesellschaft, Berlin; Emanuel Nobel, St. Petersburg; Aktiengesellschaft "Sormowo," Sormovo, Russia. The accompanying illustration shows a 150-hp. single-acting Junkers engine built by J. Frerichs & Co., in Osterholz-Scharmbeck, Germany.

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Carburetor Adjustments

By A. L. Brennan, Jr.

During the past few years gasoline engines have been improved very materially, but the quality of gasoline obtainable on the market has deteriorated and at present that supplied in some localities is very inferior. Looking at the subject broadly it may be said that the modern carburetors have maintained the efficiency of the internal-combustion motor, but have not improved it.

When carburetors were first called into use to convert gasoline into a highly combustible gas through its admixture with a given amount of air under normal conditions, no provision was made to supply artificial heat, the gasoline being highly volatile was readily taken up by the air. But the value of supplying artificial heat soon became apparent, either in the form of a hot-water jacket or by supplying hot air or both, and this was especially emphasized after the quality of gasoline started to decline. In one respect the modern carburetors are superior to earlier models, inasmuch as they are extremely flexible on one setting of the needle valve and they allow a wide range of speeds; of course, the auxiliary air valve has to be regulated in some cases.

It is impossible to lay down any fixed rules as to the proportions of gasoline and air for the best mixture, as there is no provision made for measuring these, but in practice it has been found that a mixture of high efficiency is composed approximately of one part gasoline to sixteen parts air. Since these proportions cannot be measured directly, the next best method is that of recognizing the symptoms of a faulty mixture and adjusting them accordingly.

Backfiring when attributable to a faulty mixture invariably indicates a weak mixture while sluggish operation usually points to a mixture that is over-rich.

Consider a new carburetor or one known to be out of adjustment and let it be desired to get an approximate adjustment that will allow the motor to be kept in operation until a further regulation of the air and gasoline can be had. Since the majority of carburetors are fitted with valves for controlling both the gasoline and air supply it will be quite necessary to adjust both of these and not merely the needle valve as is commonly supposed. Most carburetors operate with the needle valve open from three-quarters to one and one-half turns; therefore, if the valve is closed and then opened one turn it will generally suffice in getting the motor started at least. In regard to the air supply, a fair tension should be exerted by the air-check spring but should not be so great as to reduce the volume of gas the cylinder should get.

After making the foregoing adjustments the motor should be started. If on cranking, backfiring takes place, this would indicate too little gasoline or too much air. But in most cases this trouble will be overcome by allowing a little more gasoline at the needle valve. On the other hand, if the motor picked up its cycle but stopped in a sluggish manner, this would indicate too rich a mixture and steps must be taken to reduce the amount of gasoline fed by the needle valve. But it must be remembered that an approximate mixture must be had in order that the load can be placed on the motor, for the final regulation of the carburetor cannot be had until the motor is operating successfully under its average load.

When a final adjustment is had that allows high operating efficiency, any change that may from time to time be needed according to the speed of the engine can be taken care of by the auxiliary air valve. The needle valve should be left severely alone. This holds equally true when starting. The mixture being made slightly richer if necessary by recourse to the auxiliary air valve.

Now assuming that a good carburetor adjustment is had, which fact is clearly indicated by good operating efficiency, but that trouble unexpectedly develops which is traceable to the carburetor; this may be due to any one or more of the following:

Gasoline shut off or tank air locked;
Gasoline supply exhausted;
Water in carburetor;
Needle valve or pipe clogged;
Carburetor out of adjustment;
Low grade of gasoline;
Air intake obstructed;
Leaky manifold.

A few years ago it was not uncommon for floats to become heavy, due to fuel soaking and thus impair the efficiency of the carburetor, but this trouble is now seldom encountered as cork floats are covered with a suitable preservative and metal floats are used in many cases.

Any mechanical trouble that interferes with good compression also militates seriously against good carburetion and in order to realize good results from any carburetor the motor must be in good repair and adjustment.

REFRIGERATION DEPARTMENT

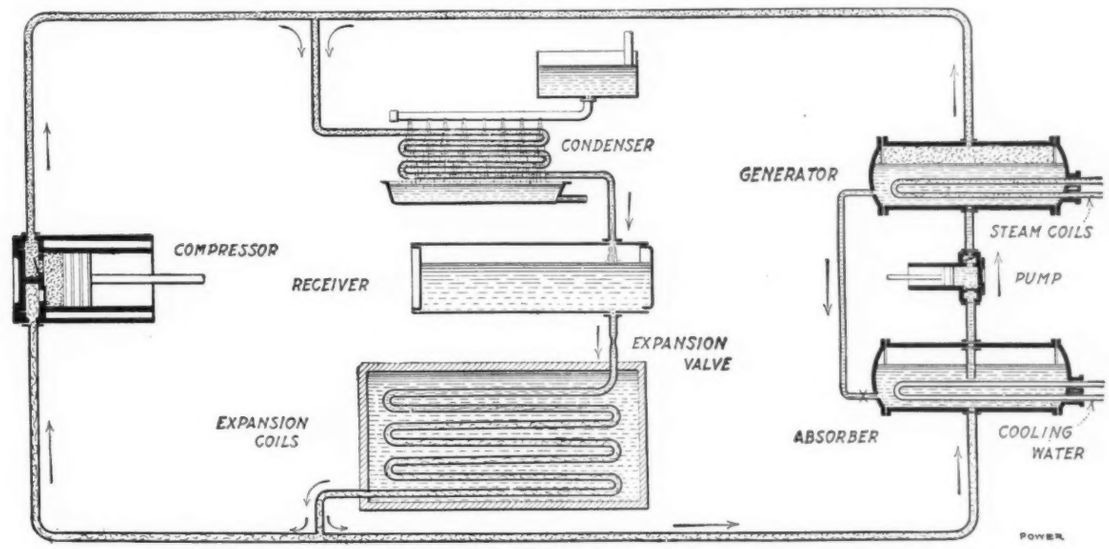
The Absorption System

Between the years 1850 and 1855, Ferdinand Carré, of France, invented the first practical ammonia absorption system. About the same time, 1855, Professor Twining, in America, and James Harrison, of Australia, independently perfected an ether compression machine, which had been invented in 1834 by an Englishman named Jacob Perkins. The absorption system took the lead, however, and for 30 years was almost universally used. Toward the end of this period, investigators began to realize how inefficient these early plants were, and turned their attention to developing the compression system. This type of plant was installed in large numbers, but the absorption system did not quite reach oblivion. The process was simple; the apparatus consisted of a number of inexpensive tanks, pipe coils and valves, and no motive power, with the exception of a small pump, was required. Improvements were made in the method of distilling and drying the gas; more of the waste heat was utilized; and the overall efficiency was considerably increased, so that the absorption system now has its place in refrigeration. Ordinarily it requires about the same amount of coal or its equivalent but a larger amount of cooling water than the compression system. Where exhaust steam is available from direct-acting steam pumps or a noncondensing steam plant, or both, the absorption system can be used to advantage. In combination with a heating load requiring about the same amount of steam, the conditions are ideal. In warm weather, the exhaust steam is utilized for refrigeration, and the balance of the year it fulfills the heating requirements.

The principle of operation is just the same as in the compression system, only the method of securing the results is different. For the compressor of the compression system, a generator, absorber and liquor pump are substituted. The balance of the system; that is, the condenser, expansion coils and expansion valve, may be similar. In practice, the brine system is generally used for an absorption plant, and either the brine system or direct expansion with the compression system.

To show the similarity between the two systems, the accompanying diagram has been prepared. The apparatus common to both, as shown in the center of the drawing, are the condenser, receiver, expansion valve and expansion coils. At the left is the compressor and at the right the apparatus which takes its place in the absorption system. Its action depends, primarily, on the high affinity of ammonia for water. At 60 deg. F., 1 cu.ft. of water will absorb about 700 cu.ft. of the vapor, and at 32 deg. and atmospheric pressure, the water will absorb 1000 times its volume.

In the issue of Mar. 11, on page 342, the cycle of events in the compression system was illustrated. From the expansion coils cold ammonia vapor was drawn into the compressor where its pressure and temperature were raised so that the boiling point would be above the temperature of the cooling water. This made it possible to condense the vapor into liquid, which was passed through the expansion valve and its pressure reduced from about 185 to 16 lb. gage. It then entered the expansion coils and remained in liquid form until it absorbed enough heat from the refrigerator to convert it into a vapor, this vapor passing on to the compressor as before.



Diagrammatic Comparison of Compression and Absorption Systems

In the absorption system, we will also start with the expansion coils. From there, the vapor passes on to the absorber, which is nothing but a cylindrical tank in which the ammonia is brought into contact with a supply of water. This water immediately absorbs as much ammonia vapor as it can hold, and, in this state, is commonly called strong liquor. The strong liquor is then pumped into the generator, or still as it is sometimes

called, for the liquid is here evaporated by means of steam coils supplied from a boiler or perhaps some source of exhaust steam. The ammonia in the rich liquor naturally evaporates more rapidly than the water, and the pressure of the vapor builds up in much the same way as steam pressure in a boiler. As with the compressor, this pressure must be high enough so that the vapor will be condensed by ordinary cooling water, this action taking place in the condenser. In liquid form, it then passes from the condenser to the expansion coils and, as before, abstracts heat from the refrigerator.

When most of the ammonia has been evaporated from the rich liquor in the generator, it is forced back to the absorber by the difference in pressure (usually 150 lb. or more) between the two apparatus. It is then known as weak liquor. From being in contact with the steam coils in the generator it is hot, and is cooled before it passes into the absorber, although the cold-water coils may be located directly in this apparatus. The weak liquor then collects in the bottom of the absorber and is ready to take up a fresh charge of ammonia vapor which, in its turn, is pumped to the generator.

This, in brief, explains the operation of the absorption system. In a plant under working conditions, there are a number of auxiliary apparatus which were not mentioned. For the sake of simplicity they were omitted, but will be included when the actual commercial plant is described.

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Winter Work in Refrigerating Plant

By Fred Ophuls

This is the time of the year in which the operating engineer of a refrigerating or ice-making plant finds time to overhaul the machinery under his care and get it ready for next season's run. To do so thoroughly and get the best results from his labors, he consults the log books which he has kept during previous seasons and these show him the short-comings of various parts of the equipment.

In these log books he should keep complete records of the coal bought, ashes removed, water, oil and other supplies purchased, and above all, the results of the plant's operation, together with an account of the conditions under which they were obtained. There he should find most of the temperature and pressure readings and quantities, such as speeds of the various engines and pumps. This data, taken together, presents a complete story of the plant. It is of vital interest to him if he wants to improve the working of his plant and make it do better every season.

Besides this story he should find under the heading "Remarks" an account of the failures of parts of the plant at various times, of some repairs which had to be left for attention until it was possible to shut down for some time, and other points of importance in connection with the overhauling of the plant.

For simplicity the following remarks will be applied to a simple steam-driven can ice-making plant, although most of the remarks refer as well to the more complicated installations. Only the machinery and apparatus peculiar to ice-making and refrigerating plants will be considered in this article.

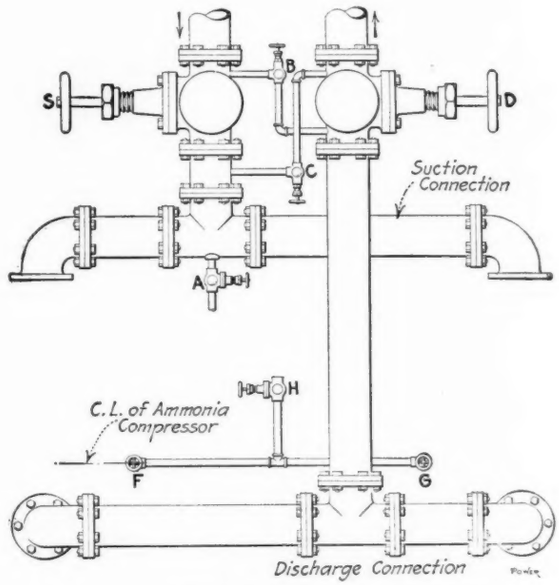
Falling Off in Capacity

In an ice-making system this can be due to a great many causes of which the following is a list of the principal ones:

1. Reduction in the pumping capacity of the ammonia compressor, caused by leakage of valves and piston, an unnecessarily low ammonia suction pressure, too much liquid ammonia entering the compressor with the vapors from the freezing tanks.

2. Disturbances in the operation of the liquifying and liquid ammonia-distributing systems, due to the scaling of the ammonia condensers and improper distribution of the cooling water over or through the condensers. In addition to this the available cooling surface of the condenser may be reduced by excessive quantities of noncondensible gases or too great or too little a charge of anhydrous ammonia. The temperature of the liquid ammonia at the point where it enters the expansion or pressure-reducing valve may be too high. It may short-circuit through a few of the brine-cooling coils or it may be impure.

3. Loss in efficiency and capacity of the ice-making system proper can arise from weak brine, the brine freezing on the brine-cooling coils, insufficient circulation of the brine, the propeller of the agitator being loose on the shaft, or having fallen from it, the level of the brine in the freezing tank being too low. It may also be due to filling the ice cans with distilled water not sufficiently cooled.



Compressor Piping

Let us look over the shoulder of the engineer and see whether or not we can learn anything of interest from the figures and notes before him. The reduction in the pumping capacity of the ammonia compressor is a serious matter and it is well to provide facilities for determining at any time whether or not the compressor and its immediate parts are in efficient operating condition. The engineer has made a slight addition in the ammonia connections around the ammonia compressor in order to attain this end. The leakage of compressor valves and the piston are difficult to determine by taking indicator diagrams, and in the accompanying sketch the ammonia connections are shown arranged in such a way that it is easy to find the causes of trouble.

It will be seen from the sketch that the ammonia suction and discharge connections are furnished with the

usual bypass or pump-out piping with shutoff valves *B* and *C*, and the ammonia compressor is also furnished with indicator or equalizing connections with stop valves *F* and *G*, terminating in the valve *H*, which opens to the atmosphere. In addition to this standard equipment a small-valved connection *A* is furnished in the suction connection to the machine.

Leakage Past Valves and Piston

To test for leakage, stop the machine and shut the stop valves *S* and *D*, as well as *B* and *C*. Then if the compressor has not been pumped out and the valve *A* is opened, the ammonia vapor contained in the short suction pipe between the stop valve *S* and the compressor escapes. Then open stop valves *F* and *G* to equalize the pressure on both sides of the piston and open valve *H* and let the ammonia vapor in the compressor cylinder escape. In case the discharge valves of the compressor are tight, the flow of ammonia from valve *H* will stop as soon as the ammonia compressor is empty. Then open stop valve *D* a turn or two and if there is no flow from valve *H*, the compressor-discharge valves are sure to be in good shape.

On the other hand, if either one of these valves leaks, ammonia vapor will flow from valve *H*, and the discharge valves must be removed, inspected and when necessary reground and repaired. In many compressor constructions the discharge valves are located in cages with separate valve seats. The joints between these parts and the compressor cylinder are either ground or made tight with gaskets. They are often the cause of the leaks as they are difficult to keep tight.

To test the suction valves, shut valves *F* and *G*, and allow high-pressure ammonia vapor to flow through the pump-out connection *C* into the compressor through the suction valves. When the cylinder is filled, shut valve *C* and open valve *A*. After the flow of vapor at *A* has stopped, find out whether or not high-pressure gas still exists on both sides of the compressor piston by opening first valve *F* and then valve *G*. If vapor escapes from the cylinder at both these points and none at *A*, the suction valves are tight. Otherwise the suction valves must be repaired.

Compressor piston leakage can be found, when all the valves are tight, by filling the compressor again with high-pressure vapor and allowing the vapor to escape from valve *F* until the flow stops. Then open valve *G* and if the piston is tight, high-pressure vapor will flow through the valve. In the event that all the vapor on both sides of the piston has escaped by way of valve *F*, the compressor piston rings and the compressor bore must be examined and repaired if necessary at the earliest opportunity.

In practice these tests do not take long, and where the size and location of the engine room permits, they should be made on each compressor at least once a month. Some engine rooms are so crowded and poorly located and ventilated that this is impossible and in these cases the indicator may be used with some success to determine leakage.

Condenser Troubles

Excessive ammonia condenser pressure always means a loss in plant efficiency. The higher the condenser pressure the greater the power to operate the refrigerating machine and the higher will generally be the temperature of the liquid ammonia leaving the condenser. It is often argued, in the case of a simple distilled water ice-making plant, that as long as the steam required to operate the machinery is just sufficient to produce the distilled water there is no economy in reducing the steam consumption of the refrigerating machine and of the auxiliaries. This is a fallacy, for about 2500 lb. of water must be evaporated in the boilers of such a plant to produce enough distilled water to manufacture a little over 2000 lb. of distilled water ice. At least 300 lb. of steam per ton of ice made is lost in the grease separator where it is removed as condensed steam with the oil used for lubrication.

To save 100 lb. of this waste would require a reduction of about 25 per cent. in the steam consumption of the engines and pumps of the plant. This saving often can be effected by reducing the condenser pressure and in various other ways, and it would mean a reduction of 4 per cent. in the coal pile, an amount which is well worth saving at the present prices of fuel.

Excessive condenser pressure can be produced by an inefficient condenser or by a good condenser under poor operating conditions. All condensers operating on the parallel flow or nearly parallel-flow principle are inefficient, whereas the counter-current-flow type will give best results. Experience with steam condensers for turbines has demonstrated that high speed of the steam and quick removal of the condensed steam from the condensing surface, are the prime factors in securing efficiency.

Too little attention is being paid to the temperature of the liquid ammonia as it leaves the ammonia condenser and as it enters the expansion valve. Every degree Fahrenheit that the liquid temperature is below the point of liquifaction in the condenser means a saving in power. It often is the case that a condenser, while producing a higher head pressure than one of somewhat different construction, will still be more economical, due to the low temperature of the liquid leaving it. This low temperature of the liquid must be preserved until it reaches the expansion valve or otherwise the benefits are lost. In case the liquid lines are of large dimensions and long and the liquid-storage tanks are of considerable capacity and located in the engine room there is often a considerable rise in the temperature of the liquid between the condenser and the expansion valve. This condition of affairs should be avoided by either relocating this part of the plant or else insulating it.

When making repairs and changes in the ammonia-condensing apparatus it is well to consider the above points and some simple calculations will enable the operating man to determine for his particular type of condenser, the most efficient condenser pressure, taking into consideration the steam required to pump the water over or through the condenser and that required for operating the refrigerating machine.

It is generally recognized that the closer the discharge and suction pressures approach, the smaller will be the horsepower per unit of refrigeration or ice making. That is to say, if the suction pressure of an ice-making system is maintained at 15 lb. per sq.in. gage and the condenser pressure could be maintained at practically the same pressure, no power would be required to circulate the refrigerating medium except that to overcome frictional resistances in the cycle. Such a condition of operation is, of course, impossible. But if the condenser pressure

can be maintained between 60 and 100 lb. the economical results of the plant will be far better than when the condenser pressure is maintained between 100 and 200 lb. gage.

The operating man with the data that he has accumulated after several years of operation can figure very readily which condenser pressures he should maintain at various times of the year for efficient operation and if the arrangement and construction of the liquid mains and their connections do not permit of operating the system with the low condenser pressures which he can obtain in the fall, winter and spring of the year, he must insist that they are changed. The change to be made is to place the liquid receivers just below the ammonia condensers and either remove the old liquid mains and connections and replace them by larger ones or else run additional lines to prevent excessive pressure drop between the liquid receiver and the expansion valves.

It is needless to call attention to the fact that scale on the condensing surface very much reduces its efficiency and when lime and other impurities are contained in the cooling water which are likely to form scale, the condensing surface should be frequently cleaned and if possible galvanized so that painting is not required. Painting condensing surfaces is not good practice as paint is a poor conductor of heat, and, moreover, does not stay on the pipe surface for any length of time on account of the excessive variations in the temperature of the pipe.

The reduction in the cooling and condensing surface on account of the presence of noncondensible gases can only be guarded against by frequent blowing off. These gases will form more rapidly as the difference between suction pressure and discharge pressure increases. While it has been often suggested to collect these gases in a separate receiver located over the condenser and connected with it, this method is not as effective as blowing off each condenser stand separately when practically all of the ammonia has been pumped back into the other stands of the condenser and the receiver. The importance of getting rid of these noncondensible gases is often overlooked by the operating man, but good practice demands that each condenser stand of a refrigerating or ice-making plant be blown down at least once every month. The loss of ammonia from this cause can be reduced to a small amount by careful manipulation and in that case the benefits of low condenser pressure will far offset the cost of the ammonia so lost.

Expansion Side of Plant

Weak brine will cause a disturbance in the circulation of the brine and also decrease the heat-conducting capacity of the freezing tank from the water in the cans to the coils submerged in the brine. It also disturbs the operation of the plant as the ice cans are liable to freeze fast to the coils.

Special attention should be paid to the circulation of the brine in the tank. It often happens on account of the inaccessibility of the brine agitator that the propellers become loose and even fall from the shafts, in which case the time of freezing the ice is increased. A great many can ice-freezing tanks lately constructed have been arranged with the necessary partitions and agitators so that the brine circulates from two to three times as rapidly as was the custom with the older construction. Care, however, must be taken not to increase the speed so much that the stability of the ice cans in the tank is endangered. In designing the brine-circulating system for a freezing tank it must be remembered that uniformity of circulation is of great importance. To operate a can ice-making plant efficiently it must be possible to draw the ice regularly. In many plants it is found that the ice freezes more rapidly in some of the cans of a row than in others, so that time is wasted in waiting for the slower cans to freeze up solid. If the circulation were uniform, the output of the freezing tank could often be increased from 5 to 15 per cent. The operating man who has had the opportunity to observe the freezing of the ice in the tanks under his care for a whole season's run will know exactly what parts of the tank freeze up more rapidly than others and by installing a wooden partition here or there in the tank or another agitator in the proper place, wonderful improvements in capacity can be obtained.

Often the level of the brine in the freezing tank is maintained too low. By watching his plant carefully the engineer can tell at what height the brine will give the best results. It must be remembered that as the ice freezes the volume of water and ice in the can increases. Some of the water still remaining unfrozen overflows the top of the ice cake and it is found that the height of the ice cake when it is frozen solid is nearly 9 per cent. higher than the body of water from which it is formed. It is also a fact that it is the water in the top of the can which it is most difficult to freeze up and by carrying the brine sufficiently high in the tank this part of the ice block can be made to freeze up solid nearly as fast as the bottom. If it is found that for such a height of brine the cans have a tendency to float, they should be secured in place either by wedges or else by using heavier cans made of say No. 14 iron with very wide bands around the tops, instead of No. 16 iron which is now the standard. The higher price of the heavier can is quickly offset by the reduction in the time of freezing.

The improper proportioning of the brine-cooling coils in the can ice-making tank often leads to unsatisfactory results, particularly when a change from the standard way of feeding the coils by means of separate expansion valves to the flooded or gravity feed system is used. A length of pipe coil which may be satisfactory when operating by means of separate expansion valves may be entirely out of proportion for good results when the flooded or gravity feed system is installed. This is the main reason why the flooded or gravity feed system has in so many cases proved unsatisfactory. If it is installed properly it will give at least as good results as feeding by separate expansion valves and in some cases even better results, due to the fact that its adjustment is more simple.

The foregoing remarks deal in a general way with some of the deductions that it was possible to make from the engineer's log. In a later issue it will be shown with the aid of some simple figures what the economies suggested really mean.

❖

Firing locomotives more economically, the aim of an educational campaign which the Lehigh Valley R.R. Co. has been conducting with its firemen, has resulted in a decrease of 5 per cent. in the amount of coal used per ton-mile in 1912 as compared with that for 1911. This is in spite of the facts that the road is running heavier trains than it was a year ago, and that many new firemen were hired in 1912.—"Engineering Record."

EDITORIALS

No Enabling Act

The engineers of New Jersey despairing, after thirty years' struggle with corporation-controlled legislatures, of ever getting a state law for the examination and licensing of engineers or the inspection of boilers or both, are now struggling for an act authorizing such municipalities as want such examination, license and inspection to effect it by local ordinances.

The argument of the advocates of this procedure is that it will be an opening wedge; that once a law of some kind is upon the statute book it will be easy to amend it and get what they want.

They are fooling themselves. Enabling acts have never paved the way to state laws, but have invariably been barriers to their enactment.

Future attempts to get a state law will be opposed by every department organized under the enabling act, with all the ardor, vigor, and systematic pertinacity of public officials fighting for their jobs.

An enabling act is not a breech in the defenses, it is an additional barricade.

If any city wants a local law, which it ought not as compared with a state law, the police and sanitary powers which it already possesses are sufficient for the establishment of a good workable department.

The uniform state law has got to come. When a few more states get laws like Massachusetts, Ohio, Montana and Minnesota, and the users of steam boilers and employers of engineers find that their object is to keep them from killing about four to five hundred folks, injuring nearly twice as many more, and destroying some half a million dollars worth of property a year, and not to make the proprietor change desks or residences with the engineer, they will look with more tolerance upon such laws and occasionally tell their legislators that they may pass an easy one and see how it will work.

⁂

Growth of Cast-iron Throttle Valve

Superheated steam having demonstrated its value in the power plant is here to stay, and will be more and more used as time goes on.

Troubles encountered in the early days of its use have been eliminated to a large extent. More suitable materials have been found for valve parts, and inordinately high temperatures of superheat have been abandoned. Today the average temperature of superheated steam used is between 100 and 125 deg. F. above that of saturated steam. At this temperature troubles in lubricating reciprocating engines have greatly diminished.

Interesting instances are found now and then where the action of superheated steam has caused trouble and anxiety to the engineer in charge. In one such a horizontal steam turbine operating under normal conditions suddenly developed a tendency to race. An investigation disclosed that the throttling valve, operated by the governor, and controlling the volume of steam admitted to the turbine was sticking, and as the governor could not operate it properly the turbine would gather speed when the valve stuck in the open position and decrease its speed when the valve finally gave way and moved toward the closed position.

This trouble with this particular turbine had occurred about every two weeks for some time previous and necessitated the removal of the valve for dressing down to fit in its chamber without binding. The trouble was caused by the cast-iron body of the valve growing under the influence of the superheated steam. One dressing would not make a permanent cure, but had to be repeated in about two weeks.

This particular valve is expected to attain its full growth in a few months, when the dismantling of the governor connections and valve will be a thing of the past. Just how much the cast-iron valve will have enlarged from the time it was first put in operation until it has reached its growth is a conjecture.

Dressing down the valve requires only about two hours, and does not affect the plant output in this case, as a spare unit can be started up, but, in a small plant, the sticking of the valve, if it became very pronounced, might tie up the entire service. A precaution against such an occurrence would be to attend to the valve at opportune times, even though sticking had not developed since the last dressing.

⁂

Feed-water Purifying Process

Human conviction is a funny thing. Many a man has been honestly convinced of a veritable impossibility, and by methods which, to him at least, must have been unquestionable and decisive.

The treatment of feed water, with respect to its scale-making qualities, is a favorite field for the exercise of this sort of hypnotism. It is possible to determine accurately how fast a boiler is scaling and positively whether a process of treatment is diminishing the rate at which scale is deposited—but nobody does it. The matter is usually one of judgment and judgment is flexible and often swayed by impalpable influences.

Some years ago there was placed upon the market a cylinder, in appearance like a small feed-water heater. All that was necessary to do was to let the feed water pass through it on its way to the boiler, and all the scale-making properties were gone. The promoters could show you any number of statements signed by reputable engineers to this effect. It was the acme of simplicity, and, if it really did what it was claimed to do and what these engineers thought it did, it would be in use in every steam plant today. So far as we know, it is not even upon the market.

A while ago, an engineer of more than ordinary intelligence told of a somewhat similar device which the inventor had installed in his plant. He was so much

in earnest about the thing, and talked so convincingly about it, that one of those who heard him called at his station when he happened in the city some months after to see it.

"The scale remover? Oh! yes," said the engineer, "we've thrown that out."

"What was the matter? Did it stop working?"

"No, it worked all right; took out most of the scale; but we opened it one day and found that there was nothing in it but a bunch of horseshoe magnets. I thought that if that was all it needed, we could magnetize the water easier than that, so I made a solenoid by wrapping some wire around the feed pipe, and I don't see but what it does just as much good as the tank."

And it probably did.

For a couple of years we have been reading of a German process of purifying water by letting it trickle over a tray of aluminum. If we remember correctly, sunlight is either requisite for or conducive to the process. Its results have been the subject for discussion by learned bodies, and most erudite theories have been advanced to account for them. We do not presume to challenge the efficacy nor orthodoxy of the process, but we cannot help wondering if it will be in evidence a half dozen years hence.

High Speed Bearings

J. G. K. Balfry, in a paper recently read before the Rugby Engineering Society, gives the following figures as representing the practice of the General Electric Co. in the design of turbine bearings:

Vel. of rubbing surfaces, ft. per sec.		Pressure allowed, lb. per sq.in.		Product
20	×	167	=	2,340
34	×	190	=	6,460
40	×	208	=	8,320
60	×	229	=	13,740
73.5	×	235	=	17,270

Engineering, from which our knowledge of the paper is obtained, calls attention to the fact that the product of the velocity and the pressure amounts to over 17,000, with the highest velocity, whereas it used to be considered necessary to keep it within 2500. The use of forced lubrication is doubtless responsible for much of this possibility of using proportionately smaller bearings with higher speed.

Mr. Balfrey's paper brings out the fact that another time-honored practice is being abandoned by some firms when designing high-speed bearings. It has been the universal practice to cut oil grooves in the brasses. The theory of the high-speed bearing, however, as developed by Osborne Reynolds, robs these grooves of any obvious purpose, and, in fact, it might not unfairly be argued that they are actually detrimental. It is, therefore, of interest to note Mr. Balfrey's statement that some makers now consider grooving of this kind unnecessary, it being, they hold, sufficient to supply oil along the whole length of the bearing at about the horizontal center line.

Safety and Responsibility

A letter recently received on the above subject told of a boiler inspector who was about to test a safety valve by comparison with his gage when the engineer suggested that the inspector's gage first be tested with a dead-weight tester which the engineer happened to have. The gage was found to read 10 lb. light. Hence if the inspector had reset the valve it would have been set for 10 lb. too great a pressure.

The letter was not printed because it seemed to make too much of what is probably a very rare happening. That an inspector's test gage should be absolutely and unquestionably correct goes without saying. So should a physician's thermometer or any other measuring instrument upon the records of which much depends. These things are so patent there is no occasion to discuss them at any length.

The remissness of one inspector should not be held up as a reflection on the profession or any one but the single inspector who was negligent. In no field will every member be found faithful to his duties. In the case in question it may not have been carelessness, but unwitting confidence in an instrument that was presumed to be correct.

The moral of it all is that since so much is expected of a boiler inspector, he must walk more circumspectly than his less exalted brothers and see to it that no one can catch him with an inaccurate instrument or any other evidence of laxity in his work. If he has no pride in the matter a sense of his responsibility for the safety of a great many lives should make him unrelenting in his diligence and carefulness.

The two large horizontal return-tubular boilers which were tested to destruction by James E. Howard, formerly in charge of the Department of Tests at the Watertown Arsenal, and now connected with the U. S. Bureau of Standards, both failed at the cast-iron manhole frames (see POWER, Dec. 5, 1911). At other tests made shortly afterward by Alex M. Gow, at Ishpeming, Mich., on boilers owned by the Oliver Iron Mining Co., the boilers failed in the same way. We understand that the boilers, which exploded recently at the plant of the Howland Pulp & Paper Co. (see POWER, Feb. 4, 1913), gave out around the manholes, which also had cast-iron frames. This appears to be a vulnerable part of the shell boiler. The use of cast iron for this purpose has been abandoned, but many boilers with cast-iron frames are still in use and should be watched.

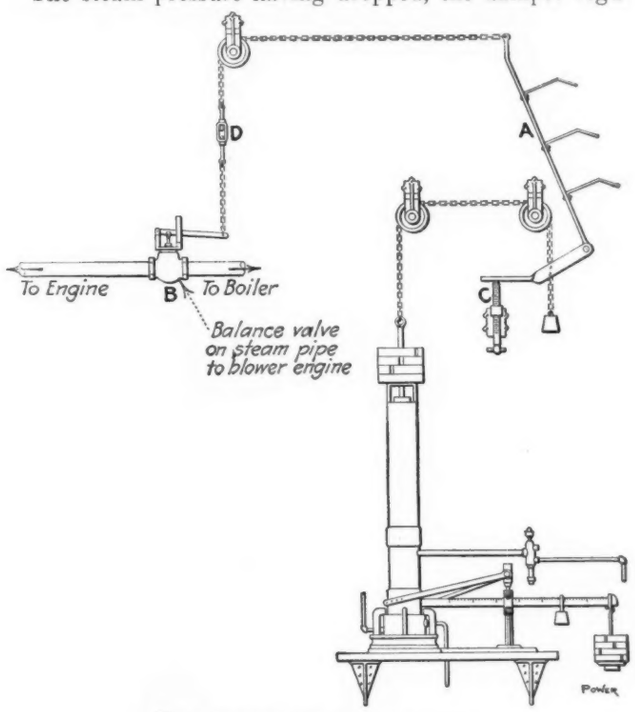
It is said that some four hundred horsepower will be required to overcome the bearing friction in the twenty thousand-kilowatt turbine which is being built by C. A. Parsons & Co. for the Commonwealth Station at Chicago. This is, however, only about one and a half per cent. of the capacity of the unit, and is equivalent to about as much heat as would be generated by burning some eighty pounds of coal per hour. The ability of the bearings to dissipate this is a striking illustration of the advance which has been made in bearings and their operation. The modern method of forced lubrication not only materially reduces the friction of the bearing, and thus the amount of heat which it generates, but the oil itself, which is circulated through a cooler, is made a vehicle for carrying off of heat at a much greater rate than that at which it could be dissipated by convection and radiation from the surfaces of the bearings themselves.

READERS WITH SOMETHING TO SAY

Forced Draft Outfit

A handy way to control forced draft is shown herewith. The steam pressure operates a damper regulator which controls the speed of the blower engine by operating a throttle valve in the engine steam-supply pipe. The arrangement works as follows:

The steam pressure having dropped, the damper regulator operates in the usual way and, as shown by the illustration, turns, by means of a wire cord and lever, the damper rod *A*, to which all of the dampers are connected. This operation also opens the balanced valve *B* in the steam line of the blower engine, and the engine speeds up.



DAMPER-CONTROL APPARATUS

When the steam reaches the pressure for which the damper regulator is set, the operation is reversed, the damper nearly closing and the throttle nearly shutting off the steam to the blower engine so it does not come to a full stop. The amount of valve opening is adjusted by the turn buckle *D*. As the blower is always running slowly the damper must be open a little to let gases pass to the stack; this opening is adjusted by the adjusting bolt *C*.

Previous to applying means of regulating the draft a small hole was drilled through the seat in the balance valve to supply steam to the fan engine when running slowly, but this was not satisfactory. The new arrangement works very successfully and requires little or no attention. We are burning three parts screenings to one of soft coal.

East Boston, Mass. CLARENCE R. DAVIS.

Thawing Frozen Water Pipes

Starting a fire in a hot-water heater to thaw the contents of the circulation pipes is not a satisfactory method of procedure as will be attested by a chauffeur who tried it recently with disastrous result.

On entering the garage the extremely low temperature of the atmosphere suggested that the grooming of the automobile could best be conducted if the said temperature should be made more congenial. Following along the line of this instinctive suggestion the chauffeur conceived the idea that the hot-water heater could be placed in commission and the desired warmth easily and quickly obtained. An examination disclosed the fact that the contents of the pipes had congealed, but what regularly qualified chauffeur would be fazed by the simple proposition of converting the ice into water and subsequently heating the water? A fire was quickly kindled in the heater and as no visible effects were expected during the transmutation an adjournment to the comfort of the furnace-heated cellar of the adjacent house was in order. Lucky chauffeur! A few minutes later a "mysterious" explosion blew out the window of the garage, bulged the rear wall outwardly a distance of 6 in., seriously marred the glossy surface of the helpless automobile and, incidently, quickly and effectively removed the partitions of what was, in the days before automobiles had become indispensable, a harness-room wherein was located the heater.

When the excitement had somewhat subsided an investigation revealed that the heater was missing, but the ice which could be seen projecting from the ends of the broken pipes proved positively that the idea of firing up the heater to thaw the frozen contents of the pipes is not practical and therefore cannot be approved.

The chauffeur states that he was examined and licensed to "have charge and operate" automobiles and not hot-water heaters, although he is fast acquiring a fund of information on what "not to do" in manipulating the latter.

CHARLES F. ADAMS.

Lynn, Mass.

Deranged Cutoff Gear

One morning one of the two Corliss engines in a certain plant began taking steam at full stroke, but it was shut down before the flywheel reached the bursting point.

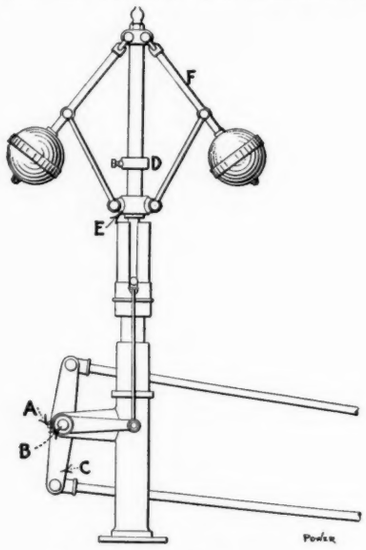
An examination of the valve-gear, etc., disclosed that the setscrew *A* in the governor arm *C* had worked loose, allowing the arm to turn on the shaft *B*. Then the steam-valve latch pushed the cam back out of the way, causing the engine to take steam full stroke.

The engineer set the arm *C* back to its proper place and marked the shaft and bell crank for future reference. The shaft and bell crank were then taken into the machine shop, a hole drilled and a pin fitted in where the

setscrew had been. This eliminated any danger from future trouble at this point.

One day at a later date, when the engineer was about to shut down the second engine, it began running at a terrific speed when the load was taken off. An examination showed that the key in the crank-end exhaust valve had worked loose. The key was driven home and after an examination the engine was started again. It came up to normal speed and then went higher as the throttle was opened.

It was noticed that when the engine was running at a little above normal speed the sleeve *E* on the governor came up against the collar *D*. That prevented the governor from going any higher, and no matter how fast the engine ran the cutoff remained the same. The engine was shut down, and the setscrew was loosened in the collar,



Troublesome Governor

which was raised ¾ in. After the setscrew was set up the governor was blocked up to the collar and the engine started, but did not come quite up to speed. Then the block was taken from under the governor and the engine now governs with or without its load.

After the collar *D* had been raised, the safety stop was moved out of the way to be sure that the governor would come down to its proper place. On some makes of governor, if the collar *D* is too high, the governor arm *F* would be held up, and if the governor belt should break or run off, the safety would be of no use.

O. L. Sherman.

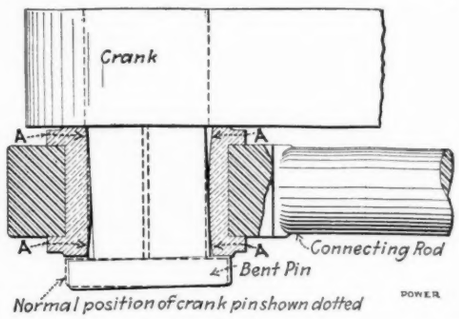
Duluth, Minn.

Running Engine with Badly Bent Crankpin

On a 10½ and 24 by 27-in. cross-compound vertical engine, the low-pressure crankpin became hot and tended to stick fast and both pin and brasses were badly scored; the crankpin was also bent. The connecting-rod end was of the marine type and no amount of oil would cool the pin, even when the bolts were slacked off two turns. With the bolts slacked off and the crankpin bent, the engine knocked very badly as it made 150 r.p.m.

While waiting for a new crankpin the trouble was overcome as follows:

The crankpin brasses were chamfered out as shown at *AAAA* in the illustration, until the rod swung evenly on each side of the crosshead-pin center in all crank positions. A little clearance was also given the brasses at the sides, so as not to allow them to bind while the engine was running. The crosshead-pin brasses were also made a little looser on the wristpin. With this arrangement



How the Brasses Were Chamfered to Allow Bent Pin to Turn Freely

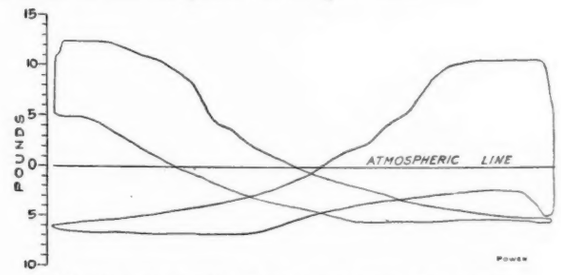
the crank brasses rolled on the crankpin as the crank rotated. The brasses were than made to fit as tight as possible without heating. This stopped the knocking almost completely and with plenty of oil supplied to the pin the engine ran without further trouble.

J. McA. Howden.

Melbourne, Australia.

How Did It Happen?

These diagrams were taken from the low-pressure cylinder of a 12x22x18-in. single-eccentric Corliss cross-compound condensing engine connected to a vertical ammonia compressor. The boiler pressure was 100 lb., receiver pressure 14 lb., vacuum 24 in., speed 90 r.p.m., and the scale of the diagram 10 lb. per inch.



Diagrams from Low-pressure Cylinder

I found, after taking the diagrams, that the exhaust valves were line and line when the wristplate was in the center, so I thought everything was all right. But, upon taking out the valves, I found they were upside down. When I put them in again, the marks came exactly line and line, the same as when the valves were upside down.

I would like readers of Power to suggest how this could have happened.

F. A. Hunter.

Provincetown, Mass.

The National Tube Co. and some other manufacturers of pipe are to start the practice of rolling their names in the pipe. This decision is coincident with that of discontinuing the rolling of merchant (lighter than standard weight) pipe, and will save the purchaser from misrepresentation while any of the old merchant pipe remains on the market.

QUESTIONS BEFORE THE HOUSE

Buckling of Boiler Tubes

My attention has been called to the letter of C. R. Summers, in the issue of Jan. 14, undertaking to criticize my comments on the buckling of tubes in the Aug. 27 issue.

His intimation that my comments were theoretical rather than practical are not to the point. Nevertheless, I might add that they are based on actual working conditions in not only one but hundreds of various experiences. He seems to have overlooked entirely the point of my argument, which was the fact that the overheating and expansion of the tubes was, in most cases, the result of the scale deposit. He even makes me say that the scale in a water tube will hold it so tightly that it cannot expand.

My statement was to the effect that, when a tube expands it naturally expands along the lines of least resistance; that a water tube usually expands upward and a fire tube downward. Naturally, certain conditions can be created or conceived that would render the opposites of this statement true. There are exceptions to all rules. In fact, I illustrated the case of the arch tubes in locomotives where the scale is on the inside, but where the tubes carry a heavy weight, in which case the tube sags.

I ask Mr. Summers to examine the two lower rows of tubes in any water-tube boiler. Those are the tubes that are subjected to the greatest heat, yet when they buckle, that buckling is invariably upward.

If my theories are at fault, I am willing to acknowledge that I am in error, but Mr. Summers' argument is far from convincing.

C. S. Davis.

Buffalo, N. Y.

Mr. Booth's Condenser Problem*

The condenser problem presented by Booth in the Dec. 17 issue is very interesting. His analyses and statements are so clear that one wonders he was unable to arrive at a correct solution.

Mr. Booth notes that if the condenser got too hot "gravity got the upper hand and stopped the injector water supply." He understands that atmospheric pressure was the force that lifted the water at ordinary times and he knows atmospheric pressure was present on a hot day; then why did the water fail to rise? Let us begin here and work along to a solution and rest assured it will bear no resemblance to perpetual motion.

When that steam engine in the cotton mill completed a stroke and the exhaust valve opened, there was thrown away into the atmosphere a cylinderful of steam at, let us say, about 4 lb. pressure. For illustration it is unimportant whether it was exactly 4 or 3 or 6 lb. Likewise, the exact value of the latent heat in that steam is not important. Let us call it 1000 B.t.u. It is important to note that this steam is absolutely thrown away by the engine; so whatever loss or gain this may occasion elsewhere, cannot be reckoned as a detriment to the engine.

Every pound of steam exhausted by the engine contains about 1000 B.t.u., and this represents energy to the value of 778,000 ft.-lb., or sufficient energy to raise 45,000 lb. of water from the pond up the 17-ft. pipe into the condenser. But 40 lb. of water to each pound of steam is a liberal allowance for circulating purposes, though only a little of that energy can be used. Most of it must flow, as heat, into the pond and there be radiated to the atmosphere. While the weather is cool, this process goes on rather rapidly, but on a hot day these heat units persist in clinging to the water. In time the water gets so "clogged" up with them that it cannot absorb them fast enough in the condenser. The vacuum falls and trouble begins.

There is, then, plenty of heat energy in the steam to lift the water, but when the water cannot absorb this energy, the work stops. It begins to look as though Mr. Booth was correct when he surmised that the energy was supplied by the steam.

Let us make one more test. Cut off the steam from the condenser; water will now be lifted, not by a vacuum in the condenser, for that has disappeared, but by the direct action of the pump. We see now that we have not obtained our vacuum for nothing. To get it we have used heat units that cost money. And, from the fact that only when the water absorbs energy from the steam can we get the vacuum, which is the cause of the lift of the water, we must conclude that the energy is really furnished by the heat in the steam that the engine cannot use.

It cannot be shown that "the vacuum was or should be a trifle less as a result of the water climbing up against the action of gravity." Three things are needed to cause a flow of fluid; a region of low pressure (relative), a region of higher pressure and a connection between the two. The water in the pond was the region of higher pressure in this case, the injection pipe the link or connecting piece, and the condenser chamber the region of low pressure. Let us say we have there a vacuum of 24 in., or, an absolute pressure of 3 lb. Out on the pond we have a pressure of nearly 15 lb. per sq.in., or a difference of about 12 lb. per sq.in. And the pressure will be sufficient to sustain a column of water 24 ft. high, or, counting friction, bends, etc., it ought to lift water 20 ft., whereas the lift to the condenser is only 17 ft. From this we see that water would flow in too freely unless we decreased the flow of the injection water by partly closing the valve. Surely it would not help matters any to pump more water into the condenser, and if water will run in too freely from the pond, which is 17 ft. below the condenser, there could be no gain from letting water flow into the condenser from a tank on the roof.

*Previous discussion of this subject appeared in the Jan. 28 issue.

Only by converting the steam back into water can the engine get the energy represented in the latent heat of its exhaust steam. So the little work the steam does in forming the vacuum cannot lessen the efficiency of the engine, and since we must waste about a thousand times the energy required to raise the water, it is not going to help the situation if we use other energy to do this work.

WILLIAM E. DIXON.

Norwood, Mass.

The condenser problem proposed by W. H. Booth can be explained by the general theory of the siphon and the jet condenser. Let us analyze this case into its elements and see what we have by not allowing any steam to enter the condenser.

We can assume that the riser is full of water. This is true because we know that theoretically the atmospheric pressure will support a column of water 34 ft. high. When there is no steam admitted the pump raises the water 17 ft. by suction, and discharges it down the discharge pipe, the length of which is 17 ft. The latter part of the work is done by gravity, and the pump is really doing no work at all, except that of overcoming the friction of the water in the pipe, elbows, etc. We have practically a siphon; the down-going water raises the incoming water. The only work which the pump does is to overcome the friction of the water in the pipe. By changing the speed of the pump we change the quantity of water pumped.

Thus far we have had practically atmospheric pressure in the condenser. Suppose now that, in addition to simply running the water through the condenser, we admit exhaust steam, which comes in contact with the spray of the incoming water and thus condenses. By condensing, the steam produces a vacuum. The reason it produces a vacuum will be clear from the following figures: A pound of steam at atmospheric pressure occupies about 27 cu.ft. This same pound of steam suddenly cooled and changed into water (by a spray, for example), will occupy less than $^2/_{100}$ of a cu.ft. Thus we see that nearly the entire space suddenly contains no matter; that is, a vacuum is formed. The pressure would fall to zero if it were not that water always has some vapor present at any temperature, and that some noncondensable gases come in with the steam. To keep this vacuum continuous the pump must constantly remove the water, condensed steam and gases.

Now let us see the combination we have, siphon and condenser together. The water is sent up the risers, not by the pump, but by the difference between the pressure at the lower end of the riser and that within the condenser. The pressure of the water in the top of the riser equals atmospheric pressure minus that due to its 17 ft. of height. Since atmospheric pressure corresponds to about 34 ft. of water, the pressure in the riser corresponds to 34 ft. minus 17 ft., that is, 17 ft. of water. Therefore, for any water to flow, the vacuum in the pipe and condenser must be less than the pressure corresponding to 17 ft. of water. This vacuum is easily attainable and corresponds to about 15 in. of mercury. For the same reason that the pressure at the bottom of the riser is equal to 17 ft. of water, that at the top of the downtake pipe is equal to 17 ft. of water. Therefore, the only work which the pump must do is to force the water and gas from the vacuum pressure (less than 17 ft. of water) against the frictional resistance offered by the pipe. The rest of the work is done by gravity in the downtake pipe.

The energy to lift the water comes from the difference in pressure that exists between the vacuum and the top of the riser. The vacuum is not at all affected by the manner in which the water gets in, whether it falls in by gravity, is pumped in, or is sucked in. The vacuum depends on the amount which does get in and on its temperature. There must be enough cold water to condense all the steam entering the condenser. The quantity of water which will flow through a pipe depends on the difference of pressure causing the flow and on the diameter of the pipe. In the case we are discussing there must necessarily be a difference of pressure between the top of the riser and the vacuum of less than 17 ft. of water. Therefore, to get a large quantity of water we would need a large pipe.

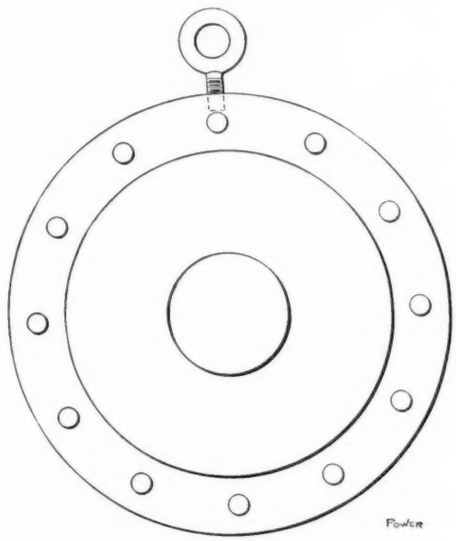
In the installation in question, the reason that "sometimes in summer gravity got the upper hand" is that the pipe was not large enough to supply sufficient condensing water, more water being needed in summer than in winter, because it is warmer and has less heat-absorbing capacity up to the temperature of the steam.

F. GITHENS.

New York City.

Removing Large Cylinder Heads

Having read of James McClure's sling for removing cylinder heads, I beg leave to submit the following sketch, illustrating a means for doing this that I have used very successfully on some large units of which I have had charge:



EYE-BOLT TO FACILITATE REMOVAL OF CYLINDER HEAD

The illustration is self-explanatory. An eye-bolt of the same diameter as the cylinder-head bolts is usually of sufficient strength to hold the head. A hook or rope may be passed through the eye-bolt when lifting off the head.

By lifting off a head in this manner the threads on the stud-bolts are not likely to become damaged, the tackle taking the weight of the head.

R. H. SCHAFER.

Trenton, N. J.

INQUIRIES OF GENERAL INTEREST

Rod Packing Thickness—Why are the stuffing boxes larger on larger engines, requiring larger packing, e.g., if ½-in. packing will hold on a rod 1½ in. in diameter why will it not hold on a rod 4 in. in diameter?

E. T. K.

The larger the diameter of a rod the greater is the circumferential length of the area to be kept packed, consequently the greater is the total elasticity required of the packing to keep it tight. The greater amount of elasticity is obtained by employing a thicker packing.

Pump Steam Consumption—Why do ordinary direct-acting steam pumps take more steam per horsepower per hour than steam engines?

L. S. W.

The larger consumption of steam pumps per horsepower-hour is not to be attributed to their not being well made, but rather to their having to take steam the full stroke, and the steam end is under other disadvantages of operation, as irregular and slower piston speed and greater waste of steam from necessary clearance spaces.

Repairing Bagged Boiler—How big a bag in a boiler would it be safe to drive back into place instead of cutting out the bag and putting in a hard patch?

A. L.

The size bag it would be safe to drive back would depend on the size of the boiler and the pressure carried. For boilers, 60 in. in diameter and upward, probably no bag larger than 10 in. in diameter nor bagging more than $\frac{1}{10}$ of its diameter should be forced back. If there is any doubt at all, it is better to cut out the bag and insert a patch with well-rounded corners.

Avoiding Static Electric Shocks—How can the shocks, due to static electricity, from belts, shafting and hangers be avoided? Does the static electricity affect motors or generators?

J. H. G.

Charges of static electricity can be dissipated by grounding some metallic part of each section affected with a gas or water pipe. A ground from a hanger will carry away the charge of static electricity from all parts in metallic contact with it. Any other section more or less insulated from the first will require a separate ground. The static charge has no effect on electrical machinery.

Meter Correction—What correction should be made to the reading of a meter calibrated to read in pounds of water at 212 deg. F., when the water is eight degrees hotter than boiling?

L. F. B.

A cubic foot of water at 212 deg F. weighs 59.833 lb. and at 220 deg. F., 59.63 lb., according to Landolt and Bornstein's Tables (1905). Hence, the reading of a volumetric meter, calibrated for 212 deg. F., should be multiplied by

$$\frac{59.63}{59.833} = 0.9966$$

to reduce it to the true weight of water at 220 deg. F.

Horsepower Constant—What is meant by the horsepower constant of an engine and how is it obtained?

I. A. R.

The horsepower constant is the number of horsepower per pound of mean effective pressure developed by an engine when running at its normal speed. It will be different for different speeds. Knowing the constant, one need only multiply the mean effective pressure (obtained from an indicator diagram) by this constant to know what indicated horsepower the engine is developing. Evidently, by the definition, the horsepower constant is all of the "PLAN" formula except the P, or

$$\frac{LAN}{33{,}000} = \text{constant}$$

which indicates, therefore, that to find the constant one should multiply the length of stroke in feet by the cross-sectional area of the cylinder in square inches, and by the number of strokes per minute (twice the number of revolutions) and divide by 33,000.

Height of Liquid in Horizontal Cylindrical Tank—To what height will 3000 gal. of water fill a horizontal cylindrical tank, 6 ft. in diameter and 25 ft. long?

K. T. E.

Presuming that the tank has one inward and one outward bumped head, its volume will be the same as if both ends were flat, and will equal

$$\frac{6 \times 6 \times 0.7854 \times 25 \times 1728}{231} = 5287.68 \text{ gal.}$$

The tank when containing 3000 gal. will therefore be

$$\frac{3000}{5287.68} = 0.567$$

part full

The area of a circle 1 ft. in diameter is 0.7854 sq.ft. and a horizontal tank 1 ft. in diameter, filled in the same proportion as the 6-ft. diameter tank when containing 3000 gal., would have 0.567 of the head submerged or

$$0.7854 \times 0.567 = 0.4453 \text{ sq.ft.}$$

This would leave.

$$0.7854 - 0.4453 = 0.34 \text{ sq.ft. unsubmerged.}$$

From a table of the areas of segments of a circle of diameter equal to 1, it is found that a segment of 0.34 area would have a height of 0.448, hence the submerged depth would be

$$1 - 0.448 = 0.552.$$

For a tank 6 ft. in diameter the depth would be

$$0.552 \times 6 = 3.312 \text{ ft.}$$

or about 3 ft. 3¾ in.

Computed Factor of Evaporation—The usual tables for factors of evaporation do not go above 212 deg. F. How can the factor be obtained when the feed water temperature is 220 deg. F.?

B. F. L.

The factor of evaporation for conditions beyond the range of the tables may be computed from the formula

$$F = \frac{H - h}{970.4}$$

where

H = Total heat above 32 deg. F. of 1 lb. of steam at boiler pressure

h = Total heat above 32 deg. F. of 1 lb. of feed water.

970.4 = Heat of evaporation, or latent heat of steam at 212 deg. F. (From Marks & Davis steam tables).

Suppose the boiler pressure to be 100 lb. gage, then the absolute pressure would be 114.7 or, practically, 115 lb. per sq.in. From the Marks & Davis tables, the value of H for 115 lb. abs. is 1188.8 B.t.u. and for h for 220 deg. F. 188.1 B.t.u. Substituting in the equation.

$$F = \frac{1188.8 - 188.1}{970.4} = \frac{1000.7}{970.4} = 1.0312$$

This shows that one factor cannot be obtained from another as given in a table by any percentage correction, but only as a difference. If tables of factors of evaporation are available for feed water at 200 deg. F., and for the existing boiler pressure, the actual factor can be computed as follows:

As the heat above 32 deg. F. in 1 lb. of feed water at 200 deg. F. is 167.94, B.t.u. and at 220 deg. F. 188.1 B.t.u., the correction is

$$\frac{188.1 - 167.94}{970.4} = \frac{20.16}{970.4} = 0.0208$$

i.e., to obtain the true factor of evaporation, when the temperature of the feed water is 220 deg. F., subtract 0.0208 from the factor for feed water at 200 deg. F.

ENGINEERS' STUDY COURSE

Mensuration—Part VII

Spherical Segment

In the last lesson we learned that the volume of a sphere is equal to its surface multiplied by one-third of its radius, because the sphere can be considered to consist of a great number of pyramids of equal altitude with their apexes all meeting at the center. If we take away enough of these pyramids we might have a *spherical sector* as in Fig. 1 and the volume of this sector would be equal to the sum of the volumes of the pyramids remaining, so that the law still holds and the volume of the sector will equal the product of the surface of the part of the sphere left (in this case a zone) by one-third of the radius. Then, given any spherical sector of known radius, we have but to find the area of the zone to be in position to determine the sector's volume.

We also learned in the last lesson that the area of a zone is

$$A = 2 \pi R h$$

where

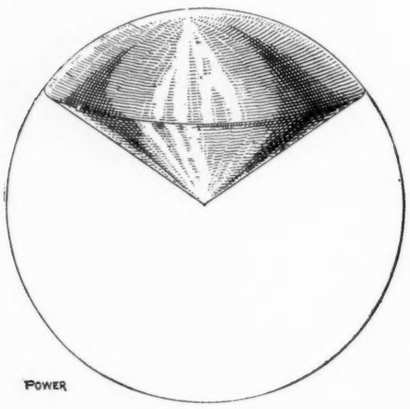


Fig. 1.

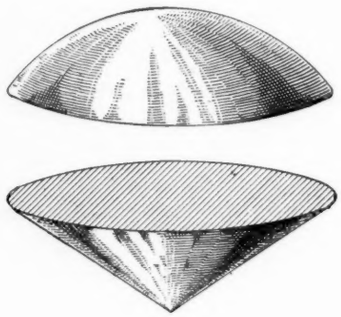


Fig. 2.

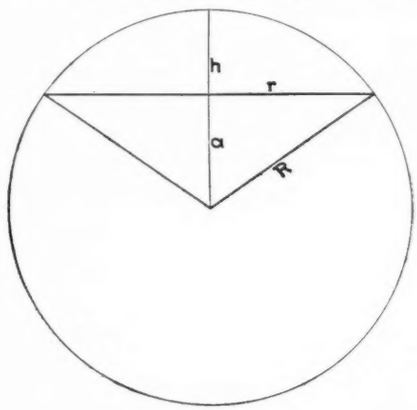


Fig. 3.

R = Radius of the sphere;
h = Height or altitude of the zone.

Now we can construct one formula for the volume of a spherical segment for we have seen that it will be

$$V = A \times \frac{R}{3}$$

Substituting the value of A and we have

$$V = 2 \pi R h \times \frac{R}{3} = \tfrac{2}{3} \pi R^2 h$$

From the forms that we have become familiar with we recognize in the spherical sector the combination of two —a spherical segment of one base and a cone—and we might separate them as in Fig. 2. Now we see at once the way to find the volume of a spherical segment of one base for we have only to subtract the volume of the cone from that of the spherical sector, both objects the volumes of which we now know how to determine.

Calling the radius of the base of the segment r, the volume of the cone is

$$V_1 = \tfrac{1}{3} a \times \pi r^2$$

where a is the altitude of the cone and equals the radius of the sphere minus the height of the segment or

$$a = R - h$$

Substituting in the last equation

$$V_1 = \tfrac{1}{3} (R - h) \times \pi r^2$$

Now, subtracting this volume from that of the spherical sector and the volume of the spherical segment of one base becomes

$$V_2 = \tfrac{2}{3} \pi R^2 h - [\tfrac{1}{3} (R - h) \times \pi r^2]$$

which reduces to

$$V_2 = \frac{\pi}{3} (2 R^2 h - r^2 R + r^2 h)$$

This formula is a bit awkward to use and involves both the radius of the sphere and the radius of the base of the segment, whereas generally only the radius of the base is known when it is desired to find the volume of a spherical segment. What we need then is to know the radius of the sphere in terms of the radius of the base.

In Fig. 3, which is a vertical section through the center of the sector, we find a right triangle formed by r, a and R and, as we learned some time ago,

$$R^2 = r^2 + a^2$$

To avoid bringing in a we will take its equivalent, $R - h$, and substitute it, then

$$R^2 = r^2 + (R - h)^2$$

which reduces to

$$R = \frac{r^2 + h^2}{2 h}$$

Now substituting this in our formula for the volume of the segment and

$$V_2 = \frac{\pi}{3} \left[2 \left(\frac{r^2 + h^2}{2 h} \right)^2 h - r^2 \left(\frac{r^2 + h^2}{2 h} \right) + r^2 h \right]$$

which is even more formidable, but this happily reduces (though we will not here go through the tedious algebraic process) to

$$V_2 = \frac{\pi}{6} h (3 r^2 + h^2) = 0.5236 h (3 r^2 + h^2)$$

which is a handy formula and may be stated as follows:

Rule: *To find the volume of a single-base spherical segment, add three times the square of the radius of the base to the square of the height and multiply the sum by the height and by 0.5236.*

In the rarer cases where the radius of the sphere is known but the radius of the base of the spherical segment is not known, we will need a formula which also may be

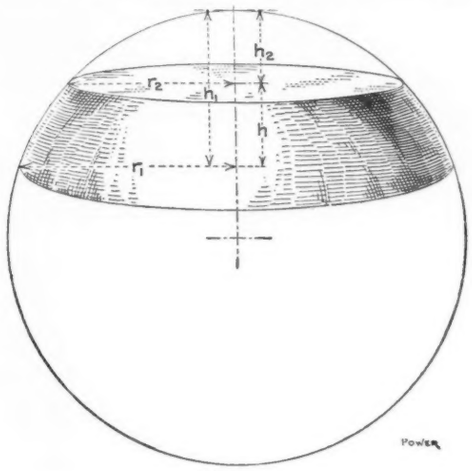


FIG. 4.

derived from the first one by substituting the value of r^2 in terms of R and h.

Going back again to the relation of the squares of the sides of a right triangle

$$R^2 = r^2 + (R - h)^2$$

this may also be solved for r^2, when it gives

$$r^2 = 2\,R\,h - h^2$$

Substituting this in the first equation for the segment volume and we have

$$V_2 = \frac{\pi}{3}\,[2\,R^2\,h - (2\,R\,h - h^2)\,R + (2\,R\,h - h^2)\,h]$$

which reduces to

$$V_2 = \pi\,h^2\left(R - \frac{h}{3}\right) = 3.1416\,h^2\left(R - \frac{h}{3}\right)$$

which, interpreted as a rule, states:

Rule: *To find the volume of a spherical segment, subtract one-third of the height of the segment from the radius of the sphere and multiply the difference by the square of the height and 3.1416.*

The last formula will be useful in the next step—to find the

VOLUME OF A SPHERICAL SEGMENT HAVING TWO BASES

Obviously the volume of a segment of two bases is the same thing as the difference between the volumes of two single-base segments, as indicated in Fig. 4, the larger one containing the smaller. Then the formula would be

$$V = \pi\,h_1^2\left(R - \frac{h_1}{3}\right) - \pi\,h_2^2\left(R - \frac{h_2}{3}\right)$$

where

h_1 = Height of the larger single-base segment;
h_2 = Height of the smaller single-base segment;

which reduces to

$$V = 1.5708\,h\left(r_1^2 + r_2^2 + \frac{h^2}{3}\right)$$

where

h = Height of the double-base segment;
r_1 = Radius of lower base;
r_2 = Radius of upper base.

Expressed as a rule this states:

Rule: *To find the volume of a double-base spherical segment, add the square of the radius of the lower base, the square of the radius of the upper base and one-third of the square of the height and multiply this sum by the height and 1.5708.*

Just to prove our formula let us take a segment with its lower base equal to a great circle and its upper base equal to zero. We know that such a segment would be half of a sphere or a hemisphere and its volume should prove to be half that of the whole sphere. Under these conditions

r_1 will equal R
r_2 will equal 0
h will equal R

Then substituting in the formula

$$V = 1.5708\,R\left(R^2 + 0 + \frac{R^2}{3}\right) = 1.5708\left(R^3 + \frac{R^3}{3}\right)$$

$$= 1.5708 \times \frac{4\,R^3}{3}$$

and since $1.5708 = \frac{\pi}{2}$

$$V = \frac{\pi}{2} \times \frac{4\,R^3}{3} = \frac{\pi}{6} \times 4\,R^3 = \tfrac{2}{3}\,\pi\,R^3$$

which, true enough, is one-half of $\frac{4}{3}\,\pi\,R^3$, the volume of a sphere.

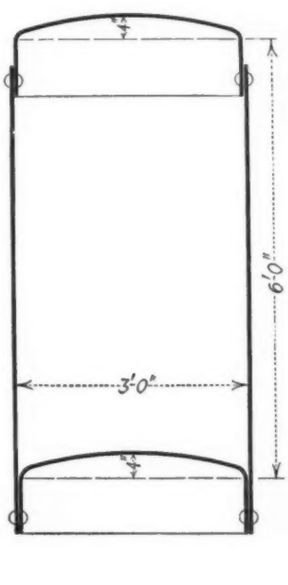


FIG. 5.

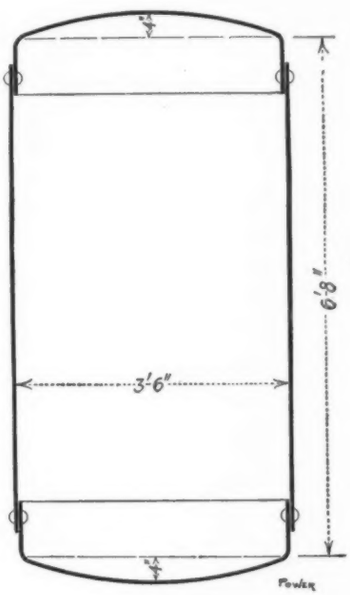


FIG. 6.

Example: What will be the volume of a two-base spherical segment, the height of which is 2 ft., the diameter of the lower base 8 ft. and that of the upper base 7 ft.?

Applying the formula, we get

$$V = 1.5708 \times 2 \times \left(4^2 + 3.5^2 + \frac{2^2}{3}\right) =$$

92.939 *cu.ft.* Ans.

Calculating Capacity of Bumped and Dished Head Tanks

The heads of bumped- and dished-head cylindrical tanks, such as those shown in Figs. 5 and 6, are usually in the form of single-base spherical segments.

We see that it is easy to find the volume of a tank with one bumped and one dished head, when the volumes of the segments formed by the heads are equal, as in Fig. 5. The volume of such a tank will be the same as that of a cylindrical tank with flat heads and whose length is the distance between the bases of the segments formed by the heads, because the increase of volume due to the bumped head is equal to the decrease of volume due to the dished head.

Hence, the volume of Fig. 5 will be

$$3^2 \times 0.7854 \times 6 \times 1728 = 73{,}287.24 \ cu.in.$$

The volume of a cylindrical tank with two bumped heads, such as Fig. 6, will equal the volume of the cylindrical part plus the volume of the segments formed by both heads. Let us calculate this volume.

The volume of the cylindrical part will be

$$42^2 \times 0.7854 \times 80 = 110{,}835.65 \ cu.in.$$

Using the formula for finding the volume of a single-base spherical segment, and substituting we have

$$V = 0.5236 \times 4\,[(3 \times 21 \times 21) + (4 \times 4)] = 2804.4 \ cu.in.$$

This multiplied by 2 will give the volume of both segments, or

$$2804.4 \times 2 = 5608.8 \ cu.in.$$

which added to the volume of the cylinder, equals the volume of the whole tank or

$$110{,}835.65 + 5608.8 = 116{,}444.45 \ cu.in.$$

Examples for Practice

(1) A knoll back of a boiler house is to be removed to permit extending the boiler house. If the knoll is shaped like a single-base spherical segment and is 50 ft. in diameter by 20 ft. high, what will it cost to remove the knoll at $1.04 per cu.yd. (one cubic yard equals 27 cu.ft.)?

(2) The pressure tank on a hydraulic elevator system has bumped heads. The cylindrical part of the tank is 12 ft. long by 4 ft. in diameter, the altitudes of the bumped heads are each 12 in. What is the capacity of the tank in gallons?

❖

Probably the most notable railway electrification project at the present time is about to be undertaken in connection with the suburban steam railways of Melbourne, Australia.

The system includes 289 track miles and, the potential selected is 1500 volts direct current. Among the reasons given for the selection of high-tension direct current instead of single-phase alternating current was that the motor-car equipment with the former is simpler; hence the maintenance will be less.

Power will be supplied from a central station at Yarraville, a suburb of Melbourne, in the form of three-phase 25-cycle current at 20,000 volts. It will be stepped down and converted into direct current of 1500 volts at 12 substations at various points on the system. The high-tension transmission is by underground cables from the power house to the substation in the central area and by overhead conductors carried on the same structures which carry the trolley wire. Roller pantagraphs will be used.

The complete system will represent an expenditure of about $12,000,000, and an American firm, the General Electric Co., has been awarded the contract for furnishing the rolling-stock equipment.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"It is hoped that some day one company and one plant will furnish all the heat, light and power in every city of the United States", says the "Wall Street Journal." Godfreys clinkers! this editor is some classy little optimist. Just as soon as this plant is ready to operate, Ignatius, we will tip you to the job as chief engineer. It ought to pull down good money, considering the responsibilities. In the meantime, hang on to your present job.

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Soon it will no longer be necessary to have the structural formation of a dachshund to see around a corner. A Berlin engineer has invented a combination of photography and telegraphy "whereby a person can see what is going on thousands of miles away." Won't ever be popular with those of us who sit up nights with sick friends.

❖

"To make two kilowatts grow where only one grew before," says "Electrical World," "is the purpose of the Society for Electrical Development." This body is big with purpose to extend the use of electricity for industrial and domestic use. Bully! It's a fine thing to be public spirited, even for a consideration, but—it would be interesting to know just how it intends to aid the development of the isolated plant.

❖

Because of short coal weights, says the Interstate Commerce Commission, the retail dealers and consumers annually lose $20,000,000. Who gets it? Can't blame Hi Stack this time. Hi never even got a look-in on this huge lump of combustion product.

❖

"Lend us a passive ear."—"Valve World."

We have a team of ears that are sound and kind, and fit for a lady to drive a whisper into, but unfortunately they won't stand without hitching. You can have almost anything else from us, neighbor, our lawn mower, a setting hen, our calabash pipe or our fuzzy hat, but our passive ear! We pray thee hold us excused.

❖

More than one kind of "juice" may be run through a conduit. A Philadelphia merchant is said to have 600 12-in. lengths of tile ducts entering the wall of his wine cellar to serve as receptacles for wine bottles. Each piece of 12x4-in. conduit holds a quart bottle comfortably.—"Electrical World."

Any operating engineer who contemplates reconstructing his wine cellar is welcome to this tip.

❖

As long ago as 1638, Spanish engineers proposed that a canal be dug across the Isthmus of Panama. If the interests of better and uniform boiler laws are under consideration as long as was the canal, some of us may lay upon the hillside, or perhaps there'll be a good working substitute for the boiler.

❖

Govanovich Sneezardski, a Pole and an electrician, has had his name legally changed to Coffin. Except as a time-saving kink, wherein lies the advantage? The first seems but preliminary to the other. Ought to get this; sneezy enough if you work it out.

❖

"For quiet service rendered," the City Club, of New York City, recently gave a dinner to that city's "faithful unknowns," men who solve problems without appreciation, shed their constancy and loyalty outside the spotlight's glare, and remain "unhonored and unsung." Some of us have to do it, and while the money compensation is mainly what we are after, there is still satisfaction in the thought that dollars and cents are not always adequate pay for what we do well and quietly.

❖

Prof. Marx, of Paris, says the aim of his life is to "show how it is possible to be happy." This is a good long-distance aim, and ought to hit some marks. Having studied the matter to his satisfaction, the learned Marx declares that a man may be happy with a broken leg. To make it a sure thing, why not break both legs? Then the patient just couldn't kick; he wouldn't have a leg to stand on.

Sarco Water Temperature Regulator

The Sarco water-temperature regulator, Fig. 1, is actuated by the expansion of a sensitive liquid hermetically sealed within a chamber into which is inserted a flexible corrugated tube.

It can be arranged to regulate the temperature of water or any other liquid where a supply of steam or hot water is used to obtain the desired temperature within any given container. The apparatus has an adjustable regulating device by which any desired temperature within given limits can be maintained constantly. The internal construction of the apparatus is shown clearly in Fig. 2.

In installing the apparatus the thermostatic element is inserted in the tank or container, the temperature of which is to be regulated, and the valve is connected in the steam or hot-water pipe, opening or closing according to the temperature in the tank.

There are three principal parts to the regulator. The thermostatic element, which is inserted in the boiler or tank, the controller element, and the valve *K*, Fig. 2.

The thermostatic element *A* is a tubular receptacle containing a heavy hydro-carbon oil into which is inserted a piece of corrugated copper tubing, the length of which

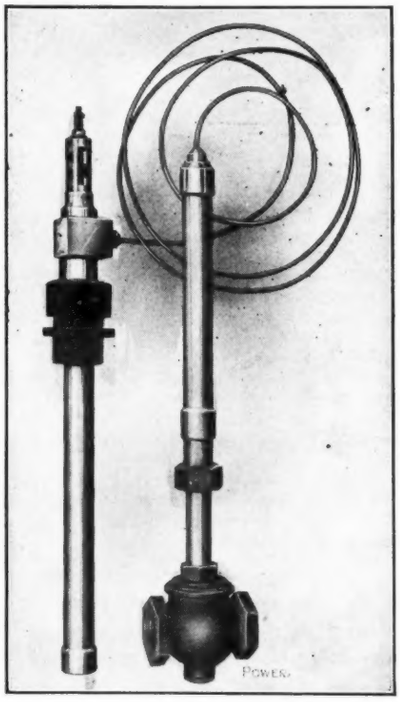

FIG. 1. SARCO TEMPERATURE REGULATOR

is extended or reduced by turning the regulator head *C*. From this thermostatic element a piece of fine copper tubing *D* passes to the controller *G*, which also contains a piece of corrugated tubing capable of compression when an increase of temperature causes the surrounding liquid in *A* to expand. The thermostatic element *A*, the connecting copper tube *D* and the controller *G* form a hermetically closed chamber. When the temperature increases in *A* the pressure increases and is transmitted to *G*, causing a compression of the copper tube *F*, which forces out the piston *I* and tends to close the valve *K*. The spiral springs *E* and *J*, operating in the opposite direction, tend to keep the valve open.

The regulator is simple and is capable of delicate adjustment, by increasing or reducing the space in which the expandable fluid is confined by extending or contracting the corrugated tube *B*.

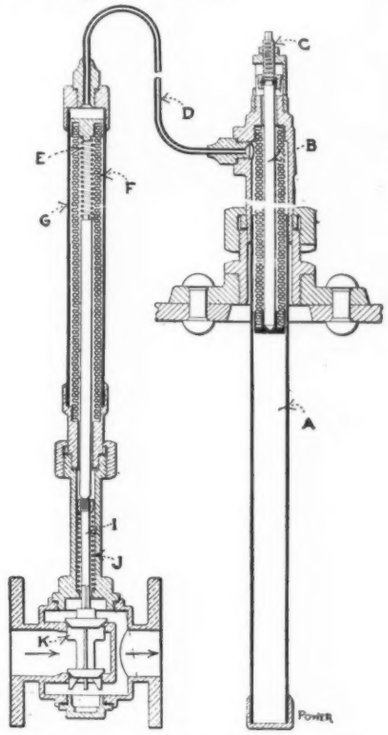

FIG. 2. SECTIONAL VIEW OF REGULATOR

This regulator is made by the Sarco Engineering Co., 116 Broad St., New York City.

Lecture on Condensing Apparatus

Members and friends of the James Watt No. 7 Association of the N. A. S. E. listened to an interesting and instructive lecture on "The Care, Operation and Troubles of Condensing Apparatus," by Brother C. H. Bromley, associate editor of POWER, at their quarters 307 West Fifty-fourth St., New York City, Saturday evening, Mar. 8.

After reviewing the types and purposes of condensers, the speaker emphasized the growing importance of condenser practice, especially in turbine operation, where high vacua are essential to economy. Mr. Bromley urged the engineers to be exceedingly careful in the operation of high-vacuum apparatus, as, because of its high initial cost, close attention was necessary to make it a well paying investment.

To assist in caring for the apparatus, a form of condenser log was shown (latern slide) which contained columns for half hourly readings of vacuum, load in kilowatts, and temperature readings of the inlet and outlet circulating water, hotwell, air-pump discharge, condenser steam inlet and condenser rear head. By keeping such a log, the speaker said, the operator could quickly locate the source of any condenser trouble.

Among the many views shown were some illustrating the latest design of marine wedge-shaped condensers, which are proving advantageous in reducing the effect of air in surface condensation.

As to packing for the tubes of surface condensers, the lecturer said that one large condenser manufacturer has adapted the fiber ferrule as superior to all others, when driven tightly into the stuffing-box.

Refreshments were served after the lecture.

NEW PUBLICATIONS

ELEMENTS OF HEAT-POWER ENGINEERING. By C. F. Hirshfeld and W. N. Barnard, Professors at Cornell University. Published by John Wiley and Sons, New York, 1913. Size 9x6 in.; 800 pages, illustrated, cloth. Price $5.

A very successful attempt is made to present in a single volume the essentials of engineering thermodynamics as well as the principles governing the design and performance of the various types of heat engines and auxiliaries.

In the first two chapters the definition and elementary laws of heat energy are presented. In connection with the laws of conservation of energy and the statement of the mechanical equivalent of heat, too much space is devoted to the discussion of the well known forms of perpetual motion. Under specific heat, emphasis is laid on the fact that the value for the mean specific heat should be used only in calculations involving the given temperature range.

The elements of steam and gas power plants, as well as the losses occurring during the transformation of heat into work are clearly explained and illustrated in chapter III. The insertion of a chapter of this character at the beginning is desirable as the understanding of the practical details should enable the reader to follow more easily the more complicated theoretical considerations in the subsequent chapters.

The laws of gases are treated in Chapters IV, V, VI and VII, and the fundamental principles of reversibility and entropy are taken up at considerable length. This is followed by a study of gas cycles, including the Carnot cycle, the Stirling and Ericson regenerative cycles, and the Otto and Brayton internal combustion engine cycles.

Chapters IX and X are devoted to the laws of vapors, mainly steam. The process of steam generation in a boiler is clearly illustrated and the steam table constants are deduced. Methods are also given for the construction of the temperature—entropy and Mollier, or heat—entropy charts.

The laws of vapors are applied in Chapter XI and XII to the study of thermal lines and vapor cycles. Comparisons are made of the Carnot cycle with gases and vapors. The authors then differentiate between the Clausius and the Rankine vapor cycles, the expansion being complete in the first case and incomplete in the latter case.

The definitions of power, efficiency and performance are taken up in Chapter XIII. The efficiencies discussed include the Carnot efficiency, the cycle efficiency, the indicated or cylinder efficiency, the mechanical efficiency, the thermal efficiency and the overall efficiency of a heat engine. Various methods of stating the performance of heat engines are given and graphical methods for representing them are outlined.

The theoretical steam engine is discussed; the difference between the theoretical and the actual steam engine being brought out also. The fundamental differences between various types of steam engines are very briefly outlined in Chapter XVII and this is followed by a consideration of governors in the next chapter.

In the chapter on valve gears the principles of the valve ellipse, the Zeuner, the Sweet and the Bilgram valve diagrams are explained. The effect of the angularity of the connecting rod is pointed out and a method is presented for correcting the various valve diagrams when short connecting rods are used. The necessity for compression to gradually reverse the pressure on the bearings and the effects of lead and early release are defined. The objections to the slide valve are indicated and the details of piston valves, multiported and balanced slide valves are illustrated. The peculiarities in the design of valve gears for high speed, medium speed and slow speed engines are then explained, including piston and balanced slide valves, independent cut-off piston and slide valves, and valve gears with oscillating valves with and without the trip cutoff.

Steam consumption curves for different methods of governing are presented and Willan's law, for the total steam consumption, is shown to hold true for engines with throttling governors. Tables showing the efficiencies and steam consumption of various types of engines are given.

Steam turbines are discussed in Chapter XXII, in which it is brought out that the thermodynamic problems in steam turbine design are centered in the nozzle, the conversion of the kinetic energy of the jet into work being a dynamic problem. The thermodynamics of the ideal steam turbine is considered, the effects of throttling and superheating being illustrated by means of the Mollier diagram. A diagram is also presented showing the relation between the available energy of the steam entering a steam turbine and that delivered by the shaft as useful work; this diagram also illustrates the various losses such as leakage, nozzle and bucket losses, windage, radiation and mechanical losses. The principle commercial types are then explained, and brief mention is made of the field of application of high and low-pressure turbine types.

Three chapters are devoted to internal combustion engines and the Otto and Diesel cycles are explained. Emphasis is laid on cylinder arrangements, carburetors for volatile fuels and vaporizers for heavy oils, methods of governing, gas and mixing valves, ignition systems, and the complete valve gear. Performance curves are also given.

Chapters XVII, XVIII and XIX are devoted to the consideration of fuels and combustion. The necessary air supply and the practical requirements for complete and smokeless combustion are explained. Grates, furnaces, stokers and burners for liquid fuels are illustrated.

Steam boilers are next taken up. The selection of a boiler is discussed and several representative types are described. In connection with the boiler performance, the authors express the equivalent evaporation both in terms of the old and the new values for the latent heat of evaporation. As the new steam table constants have been in use for the past five years, the insertion of the old values may only tend to confuse the reader.

Various forms of superheaters are next explained and means are cited for protection against the hot gases when steam is not flowing through the superheater. Draft apparatus is also described, including chimneys, steam jets and fans.

Gas producers form the subject of Chapter XXXIII. After describing the essential parts of gas producer plants the theory of the simple air producer is developed, and emphasis is laid on high temperatures, long time of contact between air, gas and hot carbon as a requirement for maximum efficiency. The practical considerations such as the caking of fuels and the fusing temperature of ash are shown to modify the theoretical requirements. Artificial cooling of producers by means of carbon monoxide and water vapor is then discussed, carbon monoxide giving a gas of more uniform composition, while water vapor is more economical. The effect of hydrocarbons in fuels, due to the formation of tar, on the practical operation of a gas producer is explained, and the cracking method of destroying the tar within the producer is illustrated.

Apparatus for heating feed water are considered and a chart is given showing the gain which can be expected. This is followed by a chapter on condensers and another upon water purification.

Chapter XXXIX is devoted to power plants and the items influencing the choice between the steam and internal combustion engine power plants are taken up.

The last chapters are devoted to a brief consideration of compressed air and refrigeration. Water injection, water jacketing and multistage compression with intercooling between stages are discussed.

In connection with refrigeration, the thermodynamics of the refrigerating machine is developed and the coefficient of performance explained. The air compression machine is described and its limitations illustrated. The fundamental principles governing the action of vapor refrigerating machines of the compression and absorption types are briefly explained.

In general the book is clear, original in the method of presentation and free from padding. The illustrations are good and aid in presenting much material in a short space.

BOOKS RECEIVED

THE GAS, PETROL AND OIL ENGINE. Vol. II. By Dugald Clerk and G. A. Burls. John Wiley & Sons, New York. Cloth; 838 pages, 5½x8¾ in.; 481 illustrations; tables. Price, $7.50.

GAS POWER. By C. F. Hirshfeld and T. C. Ulbricht. John Wiley & Sons, New York. Cloth; 198 pages, 5x7½ in.; 60 illustrations. Price, $1.25.

BOILER EXPLOSIONS, COLLAPSES AND MISHAPS. By E. J. Rimmer. D. Van Nostrand Co., New York. Cloth; 135 pages, 5¼x8½ in.; tables. Price, $1.75.

More Water for Power at Niagara

The Burton law, which expired March 4, 1913, was extended for another year by the House of Representatives on March 2, but withdrawn the following day by Senator Burton himself, states "Engineering Record." This removes not only the ban on the American diversion of water, but also that on the importation of power from Canada, increasing the latter from 160,000 to 250,000 hp.

About two years ago a treaty was signed between Canada and the United States, permitting the latter to divert 20,000 sec.-ft. of water from the Falls, but on account of the Burton law only 16,000 sec.-ft. were to be used at that time. The additional 4000 sec.-ft. now available will be split up between the Niagara Power Co., turning the wheels having been idle since the enactment of the law, and the Hydraulic Power Company. The diversion of this water through the power house wheels means an increased output in power of not less than 55,000 hp.

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Society of Superintending Engineers

The New England Society of Superintending Engineers, an organization of engineers recently formed in Boston by a number of men prominent in the engineering field, is composed of chief engineers, superintendents and master mechanics who have charge of large plants.

The objects of the society are to promote knowledge on all matters relative to the construction, operation and management of large power plants and their equipment which may be brought before it for consideration and discussion; to encourage social relations among its members; to aid each other either personally or professionally, and assist each other in a practical way in any matter affecting the members. The membership is limited to men who at the time of making application shall have actual charge of or the direct supervision of steam plants of not less than 2000 hp.

The officers are, president, George W. Walsh, chief engineer, central power station, Boston Elevated Ry. Co.; vice-president, L. H. Brown, chief engineer, Lynn power station, Bay State Street Ry. Co., Lynn; secretary-treasurer, F. L. Fairbanks, chief engineer, Quincy Market Cold Storage Co., Boston.

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American Engineers to Tour Germany

As announced in earlier issues, about two hundred of the most prominent mechanical engineers of the United States will go to Europe this summer to attend the fifty-fourth annual meeting of the Verein deutscher Ingenieure in Leipzig and to inspect the educational and industrial establishments of Germany. The object of the tour is to foster a broader commercial spirit between America and Germany.

The party will sail on June 10 on the Hamburg-American steamship "Victoria Luise," the largest and most superbly appointed cruising steamer afloat. Many friends of the engineers are also planning to sail on the steamer and will probably compose the entire passenger list. The official party will consist of 200 members of the American Society of Mechanical Engineers, accompanied by 100 ladies.

The program will include many features of interest. On arriving in Hamburg on June 21, the great shipyards will be visited. The party will then proceed next day by special train to Leipzig, where the King of Saxony will welcome it and the Verein deutscher Ingenieure will tender an official reception, at which the president of the American Society of Mechanical Engineers, Dr. W. F. M. Goss, will make the principal address.

The party will leave on June 25 for a tour of industrial Germany, visiting Dresden, Berlin, Cologne, Düsseldorf, Frankfurt, Heidelberg and Munich, including a trip up the Rhine.

Independence Day will be celebrated at Frankfurt under the auspices of the American Embassy.

SOCIETY NOTES

The spring meeting of the American Society of Mechanical Engineers will be held on May 20-23 in Baltimore. This city, with its remarkable harbor and nearness to Washington and Annapolis, is most attractive as a convention city.

At the regular monthly meeting of the American Society of Engineer Draftsmen, in the Engineering Societies Building, New York City, on Mar. 20, E. S. Houghton, a member, read a paper on "The Engineer Draftsman's Part on the Erie Barge Canal." A lecture, "The Application of Descriptive Geometry to Mechanical Drawing," by Frank Dempster Sherman, Ph. B., professor of graphics at Columbia University, was also given.

The Massachusetts Chapter of the American Society of Heating and Ventilating Engineers met in Boston, Mass., on the evening of Mar. 11 with a good attendance. The chief speaker was Frank T. Chapman, of New York, chairman of the committee on ventilation of moving picture places. A standard of laws governing such houses was discussed at length. Recommendations for legislation on minimum ventilation standards were adopted which called for a minimum of 3⅓ sq.ft. of floor area as a seating space per occupant, exclusive of aisles and public passageways; a minimum of 80 cu.ft. of air space per occupant, and that the quantity of positive supply of outdoor air be based on a minimum requirement of 15 cu.ft. per min. per occupant. The recommendations include measures for machine booth ventilation.

The program for the spring meeting of the American Society of Mechanical Engineers, at Baltimore, on May 20 to 23, has been tentatively arranged. The headquarters will be at the Hotel Belvedere and the professional sessions and social functions will also take place there. The program as now arranged is as follows:

Tuesday, May 20: 8 p.m.—Informal reception at headquarters.

Wednesday, May 21: 9:30 a.m.—Business meeting at headquarters. Regular session, with papers.
12:30 p.m.—Excursion to McCall's Ferry, dam and power house. Automobile trip, including ladies, with tea served at the Country Club.
Evening: Lecture at headquarters.

Thursday, May 22: 9:30 a.m.—Session on fire protection, at headquarters.
Afternoon: Trip over Jones' Falls conduits; inspection of sewage pumping plant; trolley trip to sewage disposal plant at Back River; exhibition of high-pressure fire service.
Evening: As guests of Engineers Club of Baltimore, the members will attend a reception and dance at headquarters.

Friday, May 23: Entire day to be devoted to a trip to Annapolis. At 2 p.m. address by Admiral H. I. Cone, A. S. M. E., Engineer-in-Chief, Bureau of Steam Engineering, U. S. N., at the Capitol.

PERSONALS

Joseph M. Burns has been appointed electrical engineer of the Morris County Traction Co., Morristown, N. J., in charge of power plants, transmission lines and overhead construction generally.

William McIlhenney, formerly assistant superintendent for the Keasbey & Mattison Co., Ambler, Penn., has accepted the position of chief operating engineer for the Ingersoll-Rand Co., Philipsburg, N. J.

Charles H. Garlick, for many years president of the National Association of Stationary Engineers, and one of the pioneers in the oil industry in Western Pennsylvania, was the speaker at the weekly luncheon of the Credit Men's Association of Pittsburgh, Penn., on March 6.

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The plant of the Warren City Boiler & Tank Co., Warren, Penn., was destroyed by fire on Feb. 24, with a loss of between $150,000 and $200,000. Five hundred men were thrown out of employment. The company will rebuild.

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Large users of coal will be interested in Bureau of Mines Bulletin No. 63, "Sampling of Coal Deliveries, and Types of Government Specifications for the Purchase of Coal," just issued. The federal government, which purchases $8,000,000 worth of coal annually, buys more than half of it under specifications and has gone deeply into the question of sampling and analyzing coal. George S. Pope, the engineer in charge of such investigations, is the author of the bulletin which may be had by addressing the Director, Bureau of Mines, Washington, D. C.

Progress of the World's Fair

Extensive preparations are under way for the international exposition to be held in San Francisco in 1915 to celebrate the completion of the Panama Canal. The Harbor View site has been reclaimed and cleared for occupancy, and the Service Building is nearing completion. The Machinery Palace, by far the largest of the buildings to be erected, will cover eight acres and contain 8,000,000 ft. of lumber, enough to floor the Exposition site three times over. The building will be one mile around and will have two miles of ornamental cornices.

Twenty-seven foreign countries and thirty-three states and territories have signified their intention to participate. President Taft urged Congress to appropriate $2,000,000 for a special building to house the administration exhibit. He also recommended such legislation as will facilitate the entry of material intended for exhibition and protect foreign exhibitors against infringement of patents and the unauthorized copying of patterns and designs.

New York has appropriated $700,000 for its participation while other states have appropriated from $100 to $50,000 to cover their preliminary arrangements. The Philippine government has appropriated $250,000 gold and Hawaii's commission has selected its building site.

Applications for exhibits have come from all parts of the world, the floor space for which amounts to 1,977,000 sq.ft.

W. D. A. Ryan, the illuminating engineer who devised the method of illuminating the Panama Canal and that of the Hudson-Fulton celebration, having experimented for several months, plans to make the illumination the most striking feature of the Exposition. One of the special features will be the introduction of jewels in the places of incandescent lights. The whole effect will be surmounted by a forty-eight electric scintillator—one for each state—which will be mounted off the main axis of the Exposition, about 500 or 600 yd. out in the water. It will be placed on barges anchored in the bay and require 60 trained men to operate the lights. These will go through many evolutions of color, and on clear nights will be visible for forty or fifty miles.

"The lighting of this Exposition," says Mr. Ryan, "will surpass anything in lighting in the world's history. The advance since the last big exposition in the science and art of electric engineering and development of electric apparatus has been so great that effects can be produced which were physically impossible five or six years ago."

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Enormous Expenditures in Water Power Development

In developing inland navigation, says a recent bulletin of the Geological Survey, the federal government alone has expended $300,000,000, and prospective expenditures exceed this sum. It is obvious that the determination of stream flow is necessary to the intelligent direction of these disbursements.

In irrigation, the government is now expending on reclamation systems about $700,000,000, and this amount is far exceeded by private expenditures in the arid West. It is further obvious that the integrity of any irrigation system is based absolutely on the amount of water available. The largest use of water is that for domestic supply, and not only quantity but quality is of prime importance. In very recent years water power has become a matter of great national moment. Before the day of improved electric transmission, the importance of water power was confined largely to the locality at which it was generated, but now it is a public utility, and as the amount of water power available is dependent on the flow of rivers, the investigation of stream flow is a prerequisite to the intelligent management of this source of energy.

The drainage of the 70,000,000 acres of swamp areas of the country is a matter of water engineering, and the study of runoff is the first consideration in any drainage project. Drained swamp lands, as a rule, become the most fertile of agricultural areas, and the reclamation of the swamps of the United States should add a value which can be reckoned only in billions of dollars.

Flood prevention, both in the contributing areas and along the great lowland rivers, is the first necessity, as the flood damage in this country is probably over $100,000,000 annually.

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A new heat indicator introduced by the General Electric Co. (Limited) consists of a paint for application to bearings or other parts of machinery and electrical apparatus, which normally is of bright vermilion, but on reaching a temperature of 120° F. shows a change of color and at 190 to 210° F. is almost black. When the temperature of the part falls below 120° F. the paint resumes its normal red color. It is claimed that the paint is practically indestructible, that it is unaffected by lubricating oils, that it prevents the formation of rust, and that the warning which it gives enables a machine to be stopped before any damage is done by overheating.—London "Times."

NEW EQUIPMENT

ATLANTIC COAST STATES

Plans are being prepared by the Worcester Electric Light Co., Worcester, Mass., for the construction of a new transformer station. Three 500-kw. transformers will be installed. Estimated cost, $20,000. R. W. Robbins is in charge of the work.

The Litchfield Electric Light & Power Co., Litchfield, Conn., is making preliminary arrangements for the installation of additional equipment in its plant. A. J. Fromholz is manager.

The New York, New Haven & Hartford R.R. Co. is considering plans for the construction of a power plant at New Haven, Conn., to supply electricity for the operation of the proposed electric line from New Haven to Boston. Edward Gagel, New Haven, is chief engineer.

The United States Light & Heating Co. contemplates the construction of another addition to its power plant at Suspension Bridge (Niagara Falls post-office), N Y.

The Phillipsburg Light, Heat & Power Co. has been granted a franchise by the city council to construct and operate an electric-light plant at Phillipsburg, N. J.

Bids will be received by the borough clerk of Sharpsburg, Penn., until Mar. 27, for furnishing power-plant equipment as follows: Two 375-kw., 2300-volt, three-phase, 60-cycle generators, complete with exciters. Alternative bids on prime movers as follows: Two 450-hp. direct-connected type simple steam engines; two 450-hp. direct-connected cross-compound steam engines; two 375-kw. steam turbo driven alternating-current generating units; complete condensing equipment; three 50-light, four ampere metallic flame arc-lamp equipments complete; one four-panel switchboard complete. Sidney Martin, Penn Bldg., Pittsburgh, is consulting engineer.

The Andrew Ramsey Corporation, Mount Savage, Md., has been granted a franchise to construct and operate an electric-light and power plant at Ellerslie, Md.

SOUTHERN STATES

The city of Spencer, N. C., has been granted permission to issue bonds for $50,000, for the construction of a municipal electric-light plant and water system.

The J. B. McCrary Co., Atlanta, Ga., is preparing plans for the construction of an electric-light plant at Rochelle, Ga. W. C. Carter is city clerk.

The town council of Milton, Fla., is considering the proposition to issue $40,000 in bonds, for the construction of an electric-light plant and water system.

An expenditure of $400,000 is planned by the Tampa Electric Co., Tampa, Fla., for improvements including additions to its power plant and the installation of new equipment. J. C. Woodsome, Tampa, is local manager.

J. M. Riley has been granted a franchise to construct and operate an electric-light plant at Williamstown, Ky.

CENTRAL STATES

The State Legislature has approved an appropriation of $16,000 for the installation of boilers in the Indiana Reformatory at Jeffersonville, Ind. D. C. Peyton is superintendent.

The citizens of Broadhead, Wis., recently voted to issue $40,000 in bonds for the construction of a municipal electric-light plant.

WEST OF THE MISSISSIPPI

The city council of Greenfield, Iowa, will award contracts about Apr. 11, for the construction of a municipal electric-light plant. J. B. Hill, Iowa City, Iowa, is consulting engineer.

The city council of Low Moor, Iowa, is considering plans for the construction of a municipal electric-light plant. John T. Chandler is city clerk.

Plans are being prepared for the construction of a municipal electric-light plant at Preston, Iowa. Bonds for $8000 were recently voted for the purpose. J. B. Hill, Iowa City, Iowa, is consulting engineer.

Plans are being prepared for the enlargement and extension of the municipal electric-light plant at Spencer, Iowa. K. C. Gaynor, Sioux City, is consulting engineer.

The city of Paynesville, Minn., is considering the improvement and extension of the municipal electric-light plant and water system. John H. Haregan is city recorder.

The construction of an electric-light plant at Binford, N. D., is under consideration.

Plans have been prepared and are being considered by the city council of Mayville, N. D., for the improvement of the municipal electric-light plant.

The local electric-light and power plant at Sinton, Tex., has been purchased by the Coleman-Fulton Pasture Co. The new owners are considering extensive improvements to the plant and system.

Plans are being prepared by the Corvallis & Eastern Ry. Co. for the installation of new equipment in its power plant at Corvallis, Ore.

Plans are being prepared by the Pacific Light & Power Co. for the construction of a power plant to generate 8000 hp., at Azusa, Calif., on the Main River.

The board of trustees of Mountain View, Calif, has decided to call an election to submit the proposition to issue bonds for the construction of a municipal electric-light plant to the voters.

The proposition to construct an electric-light plant at Venice, Calif, is being considered by the city trustees.

CANADA

The city council of Amqui, Que., is planning the construction of a municipal electric-light plant.

The installation of additional equipment in the municipal electric-light plant at Glace Bay, N. S., is under consideration.

Preliminary arrangements are being made for the construction of a water-works system at Brighton, Ont., to cost $5000. T. C. Lockwood is clerk.

Plans are being prepared for the installation of additional equipment in the municipal electric-light plant at Vingham, Ont. Estimated cost, $7000. J. T. Groves is town clerk.

Plans are being prepared by [illegible] architect, Edmonton, Alta., for the construction of an addition to the municipal power plant to provide additional power required for the operation of the proposed municipal railway extension. Estimated cost, $485,000.

The city of Crowley, Alta., contemplates the expenditure of $10,000 for the installation of a water-works system.

The British Columbia Electric Ry. Co. will build a new power distributing station at New Westminster, B. C. J. B. Ingersoll, Vancouver, B. C., is electrical engineer.

The city of Vernon, B. C., contemplates an expenditure of $50,000, for the construction and equipment of a municipal electric-light plant. D. G. Tate is city clerk.

BUSINESS ITEMS

E. A. Keithley, Pacific Coast representative of the Pittsburgh Valve Foundry & Construction Co., the G. M. Davis Regulator Co. and the Central Foundry Co., whose office is located in the Rialto Building, San Francisco, has recently made a 30-day trip along the Pacific Coast in the interest of the above mentioned companies.

The Illinois Stoker Co., Alton, Ill., has issued a catalog describing their chain-grate stoker and including an analysis of practically all the different kinds of coal mined in this country. For each coal the moisture, volatile, fixed carbon, ash, sulphur and heat units are given. There is also given a table showing the evaporation per pound of coal and the pounds of coal per horsepower-hour for coals containing 7500 to 14,500 B.t.u. per lb., and for efficiencies of boiler ranging from 50 to 80 per cent. This data should be very useful to all power-plant engineers, and a copy of the catalog will be gladly sent upon application.

"Superheating" is the title of a 16-page pamphlet published by the Heine Safety Boiler Co., St. Louis, Mo. The first part of the pamphlet is a reprint of a paper from the "Journal" of the Engineers' Society of Pennsylvania, discussing the steam and fuel economy of superheating, the various designs of superheaters, the methods used for obtaining control of the temperature of superheat, and a brief description of the design and operation of the Heine superheater. The last part of the pamphlet is devoted to abstracts from the Transactions of the American Society of Mechanical Engineers on the effect of superheated steam on cast iron. These notes give examples of the serious effects of fluctuating steam temperatures and excessive temperatures. Copies of this pamphlet will be sent to engineers on request to the Heine Safety Boiler Co., St. Louis, Mo.

WANTS

Positions Wanted, three cents per word, each insertion
Positions Open, five " " " " "
For Sale, five " " " " "
Miscellaneous, ten " " " " "
No abbreviated words allowed.
Count three words for keyed address.
All advertisements payable in advance.

Copy should reach us not later than Tuesday 10 A. M., for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, will be forwarded.
No information given by us regarding any advertiser's address. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondent.
No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for positions.

POSITIONS OPEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M.M. Co.," Power.

CHIEF ENGINEER WANTED for an isolated electric plant, consisting of Curtis turbines, 3000 kw.; state age, experience and salary expected in application. P. 843, Power.

CHIEF ENGINEER, large power plant; must be good mechanic and understand prime movers thoroughly; give detail of experience and present work and salary. P. 857, Power.

MASTER MECHANIC wanted for large pulp and paper mill now under construction; must have thorough knowledge of machinery installation; state experience and wages required. P. 856, Power.

AGENTS to sell on commission mechanical draft blowers; prefer men who handle on similar basis sales of grate bars, tube cleaners or other boiler accessories; hustlers wanted; state experience and territory worked. P. 855, Power.

POWER ENGINEER wanted for manufacturing company in southwestern New York, having practical experience with electricity, compound Corliss engine, surface condenser, pumps, etc; engineer responsible for power equipment and must be familiar with economy of operation of boiler plant; state age, training, experience and salary requested. P. 854, Power.

POSITIONS WANTED

ALL-AROUND MACHINIST, thoroughly experienced on internal-combustion engines, now in charge of 700 kw. gas producer plant, desires change, assistant to chief large plant, or charge of medium size plant. P. W. 859, Power.

FOR SALE

22x48 BROWN CORLISS ENGINE, wheel 16'x27", left-hand; condition like new; $800. Duzets & Son, Hudson Terminal, New York.

KENNICOTT TYPE K WATER SOFTENER, 750 gal. per hour; never used; cheap; crated, ready for delivery. D. S. Holcomb, 60 Centre St., New York.

WHITE & MIDDLETON GAS ENGINE, first-class condition; bore 6½, 12 hp.; will sell very cheap; exceptional opportunity. Write Frank F. Pels & Co., New Durham, N. J.

METROPOLITAN ENGINE in very good condition, only been used a very short time; size, 10x14; will sell very cheap; exceptional opportunity for right party. Write Frank F. Pels & Co., New Durham, N. J.

BOILERS—4-550HP Edgemore, 2-300KWB&W with Stokers, 5-225HP Heine, 4-200HP Stirling bargain, 2-180HP Heine, 2-100 HP Heine Engines, Boilers, Generators, etc. Harold R. Wilson Machinery Co., 417 Pine Street, St. Louis.

ONE 150-kw. unit, 600-volt, three-phase, 60-cycle General Electric generator; belted to Westinghouse compound engine; one 150-hp. Westinghouse compound engine for belt drive; one Ingersoll-Sergeant steam driven air compressor; capacity, 258 cu.ft. per minute. F. S. 838, Power.

ON ACCOUNT OF CHANGING OVER from heavy work to light work on a group of buildings, we have for sale 650 hp. in boilers of a total plant capacity of 1250 hp.; these boilers are about 12 years old and are in good condition, and a Green chain grate automatic stoker goes with them. They are designed for 150 lb. steam pressure, and the specifications are as follows: Two 250-hp. Stirling boilers, Stirling Print D-8542; one 150-hp. Stirling boiler, Stirling Print D-1492; chain grate stoker shown on Green Engineering Co.'s Drawing C-207. Address the Youngstown Sheet & Tube Co., Youngstown, Ohio.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents, 904 G St., Washington, D. C.

WANTED—GENERATOR AND ENGINE of 150-kw. capacity; must be in first-class condition; give description and how long in use. M. 849, Power.

WANTED—MACHINERY CATALOGS for file at Pacific Pass Coal Fields, Ltd., via Bickerdike, Alta., Canada, and at Central Office, Hull Building, Lethbridge, Alta.

A FIRST-CLASS GERMAN MANUFACTURING AND SELLING CORPORATION for years engaged in manufacturing industrial filters, tanks, and their accessories, has increased its plant and wishes to have the exclusive rights in Germany to manufacture and sell a few patented steam plant and water supply specialties; references exchanged. Send catalogs, information, etc., to M. 858, Power.

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One of the many proofs we have of this is in the number of requests we have had to exchange the imitator's so-called Thompsons for our genuine American-Thompson Improved Indicators.

EVERY Engineer should have an Indicator:—indicator diagrams are a trade-mark of the craft—and the BEST is the only one to buy.

When we offer you our American-Thompson Improved Indicator on easy payments (we not only offer you the BEST but the original and only genuine J. W. Thompson) we do it ONLY to gain your good will and acquaint you with the meaning of AMERICAN QUALITY.

Send for "PROGRESS" (by Hubbard) and our INDICATOR BOOK. Mention both.

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